Boating Skills and Seamanship

United States
Coast Guard Auxiliary

SIXTH EDITION

Boating Skills and Seamanship

United States Coast Guard Auxiliary

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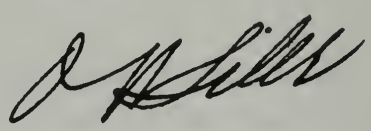
FOREWORD

It has long been recognized that knowledge is the route to greater boating safety and increased boating pleasure. With this conviction the Coast Guard Auxiliary strives to reach and teach as many of the boating public as possible. The rapid growth of recreational boating makes this no easy task, but one well worth the effort in terms of problems avoided and lives saved.

This text, prepared by the Auxiliary, is a comprehensive course, expanded to include new areas in the realm of boating activity. The Boating Skills and Seamanship course is designed to awaken new safety awareness and provide for greater proficiency that will make the boating experience more safe and trouble free.

As Commandant of the United States Coast Guard, I strongly commend the Auxiliary for its concern for safe boating and for the development of this course, which I heartily recommend to all boatmen as a step toward safer recreational boating on America's waters.



O. W. SILER
Admiral, U. S. Coast Guard
Commandant

Preface

Because it believes that the greatest deterrent to a full and enriching enjoyment of pleasure boating is the lack of knowledge required to face up to the problems which present themselves, the United States Coast Guard Auxiliary has prepared this text for its BOATING SKILLS AND SEAMANSHIP public education course.

The text is unique. The Auxiliary has drawn on the cumulative experience of its more than 45,000 members in determining the scope, depth and manner of presentation of the subject matter needed to satisfy the requirements of pleasure boating enthusiasts in all areas of our country.

The subject matter is prepared in a comprehensive yet basic manner. It is broad enough in scope to enable you to cope with almost any situation which may present itself. It is our sincere desire that your use of this text and your participation in the BOATING SKILLS AND SEAMANSHIP course will add more enjoyment to your pleasure boating.

The education efforts of the Auxiliary do not stop at public education. The quality of this text is indicative of the more comprehensive texts which are part of our advanced membership training program.

We thank the members of our Department of Education for their untiring efforts to make this BOATING SKILLS AND SEAMANSHIP course interesting, informative and educational. The guidance, cooperation and assistance of the United States Coast Guard in the preparation of this text are also gratefully acknowledged.

A. A. Cordill

A. A. Cordill
National Commodore
United States Coast Guard Auxiliary

September, 1975

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Boating Skills
and
Seamanship

CHAPTER 1

The Safe Way to Boating Enjoyment

Introduction

Pleasure boating as a family sport is growing in popularity with each passing day. Our modern industrial technology has given us more leisure time than ever before in our history. As a result, American families in ever-increasing numbers are turning to the water for their recreation. They are finding that boating is one of the few outdoor sports that can be enjoyed as a family—it's as much fun for mom and dad as it is for the youngsters.

In recent years, refinements in hull design and modern production methods have placed safe, well-designed pleasure craft of every description within the reach of a vast multitude of Americans. It is safe to say that if the present trend continues we will soon become a nation of boat owners.

In order to serve the needs and comforts of our expanding boating population, marinas and marine facilities can now be found on every body of navigable water in the country. These marinas offer a variety of products and services to help make it pleasant and convenient for families to enjoy the sport of pleasure boating. Reputable manufacturers and dealers of marine products offer an endless array of equipment and accessories to make our boating safer and more trouble free. In addition, several boating-safety oriented organizations now make it possible to learn the rudiments of safe boating in an organized manner in classes designed especially for the beginner-boatman. The United States Coast Guard Auxiliary is among the leaders in this endeavor. The purpose of these courses is to introduce to all owners and operators of pleasure craft, safety requirements and safe practices in the operation and navigation of their boats. The secret of boating safety is *KEEPING OUT* of trouble rather than *GETTING OUT* of trouble after you get into it.

Boating Accidents

Unfortunately it is a fact that some of our pleasure boatmen do manage to get into trouble afloat and, in some cases, end up as "statistics" in the local press.

Every year the United States Coast Guard publishes a BOATING STATISTICS REPORT. This report is called Coast Guard Publication CG-357, and copies of this report are available to the public on request to Commandant (G-BD), U.S. Coast Guard, Washington, D.C. 20590. This report covers accident reports from all fifty states and also includes the Virgin Islands and Puerto Rico.

In 1973, for example, there were 5,322 boating accidents involving 6,738 vessels. These accidents resulted in 1,754 fatalities, 1,599 personal injuries and over 11.4 million dollars in property damage. A lot of lives, injuries and money! Can this be prevented? The answer is an emphatic YES! Most boating accidents are the result of a lack of knowledge on the part of the boatman. Let's look briefly at the record in each category.

Fatalities

The record shows that year after year more lives are lost as the result of vessels capsizing than any other type of casualty. Why do vessels capsize? In most cases it's the operator who is to blame. Improper loading and overloading are the principal reasons, and ignoring weather warnings ranks next. Unfavorable weather and sea conditions which exceed the capabilities of the craft and the operator's training or experience cause many boats to capsize. Even under the best of conditions, if a boat is overloaded or improperly loaded, it can (and all too often does) capsize without warning.

Weight Carrying Capability

When loading your boat, weight should be evenly distributed from bow (front) to stern (back) and athwartships (from side to side). The more weight you put into a boat, the deeper it sinks into the water, thus reducing the amount of freeboard. Freeboard is the vertical distance from the gunwale (pronounced gun'l), or top edge of the hull, to the water. The more you reduce the freeboard, the greater the tendency to swamp (fill with water) or capsize. If a boat is overloaded or improperly loaded it will usually be difficult to steer. Many boats today have a capacity plate, generally on the instrument panel where it can be easily seen, which indicates its weight-carrying capacity. Remember, this is the recommended maximum weight. Whether you should carry this amount of weight depends on several factors.

The first factor to consider is the anticipated sea-state, or water conditions. It is logical to deduce that if rough water is expected, less weight should be carried. A heavily laden boat will ship water more easily than one which is riding higher in the water.

The second factor to consider would be the activity in which you expect to engage while under way. For instance, if you wanted to do some fishing it's possible that persons will stand up occasionally in the boat. Standing up in a small boat is not especially dangerous if it is done carefully in calm water conditions, and if the boat is not too heavily laden. By standing up you will change the center of gravity of the boat and, if the hull is being buffeted about appreciably, it could cause the boat to capsize, or for you to fall overboard.

Other factors would be the weight of the equipment, fuel, tools, food and other gear which will be carried. The more gear that is loaded aboard, the less passenger-carrying capacity you will have left. A rough guide for weight-carrying capacity would be as follows:

Boat Length	*Number of Persons OR Maximum Weight Load*
10 feet	2 — 410 lbs
12 feet	3 — 575 lbs
14 feet	4 — 740 lbs
16 feet	5 — 975 lbs

In the absence of a capacity plate, there is a rough double check which, if properly used, could help prevent overloading:

1-1 Overpowering and Improper Loading Resulted in this Swamping.

First, a check on the number of persons:

$$\frac{\textit{Boat length in feet x maximum width in feet}}{15} = \text{(No. of persons)}$$

The results, taken to the nearest whole number, give the number of persons that can be carried safely in good weather conditions. This readily-calculated expression gives reasonable results for a wide variety of boat types

Second, one must also check to be certain that the weight-carrying capacity is adequate for that number of persons, taking into account their actual weight in addition to the weight of the engine, fuel and equipment.

The weight-carrying capacity of a small boat having a conventional hull can be checked by determining the allowable weight in pounds as follows:

7.5 x L x B x De = ...(Allowable pounds for persons, engine, fuel and equipment)

In the above, let: L = Overall length in feet and tenths of feet
B = Maximum width in feet and tenths of feet
De = Minimum *effective* depth of the boat in feet and tenths of feet

Measure "De" vertically at the lowest point that the water can enter. This is usually at the stern or at the transom cut-out.

After you have obtained the weight-carrying capacity of your boat, either by using the above formula or by reference to the capacity plate, check the total intended load against this limit by completing the following table:

TOTAL WEIGHT CAPACITY TABLE

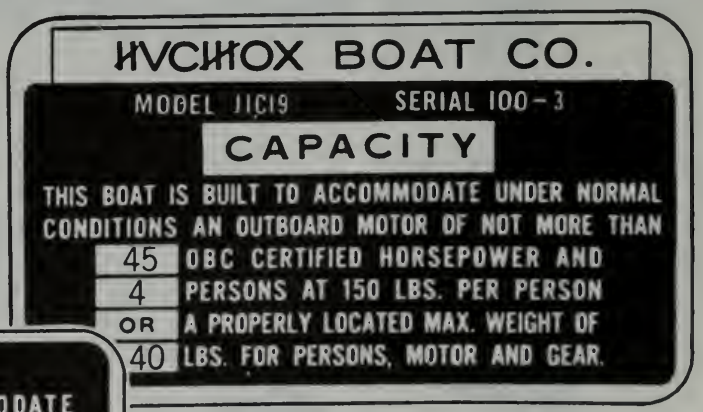
1.	Weight-carrying capacity of boat	..... lbs
	Add weight of:	
	Motor	lbs
	Battery	lbs
	Fuel tank and fuel (gas = 6 lbs/gal)	lbs
	Equipment, anchor, oars, radio, etc	lbs
2.	Total	..... lbs
3.	Remaining weight available for persons (Subtract 2 from 1)	..... lbs

BUT NOT MORE THAN

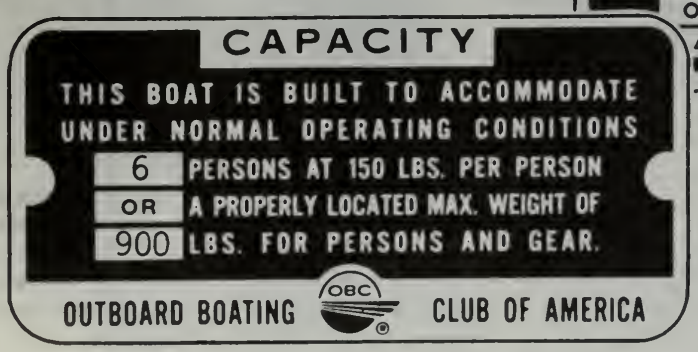
$$\frac{\textit{Boat length in feet x maximum width in feet}}{15} = \text{(No. of persons)}$$

In a particular loading situation you should observe whichever value sets the lower limit.

1-3 OUTBOARD PLATE



1-2 INBOARD OR INBOARD/OUTBOARD PLATE*



*This plate is one type offered to participants of the OBC Boat Rating Program.

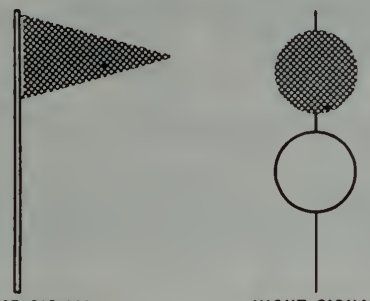
For rough weather conditions it is advisable to carry considerably less than the maximum allowable weight. If rough water is expected, one should give serious consideration to whether the boat should be used at all. This is particularly true for boats under ten feet in length which may be suitable for calm conditions only.

Weather Conditions

At selected locations in and near boating areas, storm warnings are displayed by flag hoists or lights. Display points may be Coast Guard stations, marinas, lighthouses or municipal piers. Boatmen should become familiar with the display points in their area and the meanings of the signals displayed. The small craft advisory is a red triangular pennant by day and a red light over a white light by night. The display of this signal means that conditions are expected to be unsafe for small craft. Don't ignore this warning.

As an aid to boatmen in getting weather information, the U. S. Weather Bureau publishes *COASTAL WARNING FACILITIES CHARTS* for local areas on the Atlantic, Pacific and Gulf Coasts as

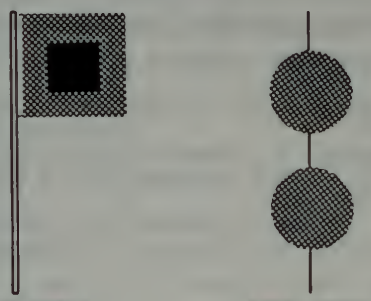
SMALL CRAFT



DAYTIME SIGNAL NIGHT SIGNAL

One RED pennant displayed by day and a RED light over a WHITE light at night to indicate winds as high as 33 knots (38 m.p.h.) and/or sea conditions considered dangerous to small craft operations are forecast for the area.

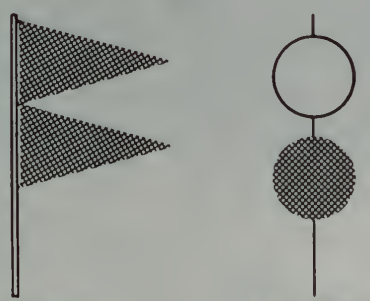
STORM



DAYTIME SIGNAL NIGHT SIGNAL

A single square RED flag with a BLACK center displayed during daytime and two RED lights at night to indicate that winds 48 knots (55 m.p.h.) and above are forecast for the area. If the winds are associated with a tropical cyclone (hurricane), the "Storm Warning" display indicates winds 48 to 63 knots (55 to 73 m.p.h.) are forecast.

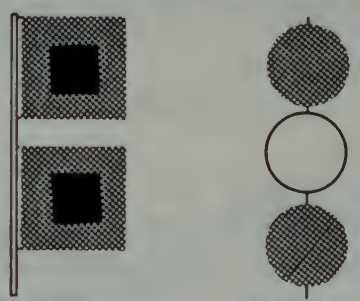
GALE



DAYTIME SIGNAL NIGHT SIGNAL

Two RED pennants displayed by day and a WHITE light above a RED light at night to indicate winds within the range 34 to 47 knots (39 to 54 m.p.h.) are forecast for the area.

HURRICANE



DAYTIME SIGNAL NIGHT SIGNAL

Displayed only in connection with a tropical cyclone (hurricane). Two square RED flags with BLACK centers displayed by day and a WHITE light between two RED lights at night to indicate that winds 64 knots (74 m.p.h.) and above are forecast for the area.

1-4 Warning Display Signals

well as the Great Lakes, Puerto Rico and Hawaii. These charts give the locations and telephone numbers of all Weather Bureau offices and the location and time schedules of all AM, FM and TV stations that broadcast marine weather information. Also included are the weather broadcast schedules of marine radiotelephone stations and air navigation radio stations. Additionally, the location of all storm warning display stations are also shown, with an explanation of their meanings. These charts can be obtained by writing to the Superintendent of Documents, Government Printing Office, Washington, D.C., 20401, and stating the local area desired. Each chart costs ten cents.

Weather sense begins before leaving your slip. Most centers of boating activity have a nearby Weather Bureau office which provides marine weather forecasts by phone 24 hours a day. A phone call to the local weather bureau should be a part of every boatman's routine preparations before casting off. All Coast Guard radio stations that broadcast routine weather and marine information do so on frequency 2670 kHz. These broadcasts are usually made at scheduled times and are preceded by a preliminary call on frequency 2182 kHz announcing the forthcoming weather broadcasts on frequency 2670 kHz. Urgent warnings are transmitted immediately and may be sent on frequency 2182 kHz. If you are underway and happen to miss the Coast Guard weather broadcast, you may still be able to get your weather from the local telephone company marine operator by radiotelephone at nominal cost.

Falls Overboard

Falls overboard and vessel sinkings were the second and third major types of casualties resulting in boating fatalities. As a boat operator, you must recognize these dangers and learn how to avoid them. As stated previously, improper loading and overloading are the principal causes of falls overboard and vessel capsizings.

Collisions

Of 829 (1972) personal injury cases, about half were attributed to collisions. The principal cause of a vessel colliding with another vessel or with a fixed object is failure of the operator to maintain an efficient forward lookout. Water skiing has contributed significantly to this problem. It's impossible to watch the skier and the area ahead of the boat at the same time. Some states have enacted laws which

1-5 Speed and Inattention

require a wide-angle rear view mirror, or a second person in the boat to watch the skier. Some states also limit the number of skiers that may be towed at one time.

If your boat is equipped with an automatic pilot, don't set it and forget it. An automatic pilot is an ingenious instrument but it will not steer around obstructions nor take over for you in a potential collision stiuation with another boat. There is no mechanical replacement for the operator.

Fires and Explosions

Fires and explosions resulted in the second largest number of personal injuries. A number of things can cause a fire aboard your boat. Among these are careless smoking, spontaneous combustion caused by oil or gasoline soaked rags or paper left aboard instead of being disposed of on shore, an electrical short, a flame-up of the galley stove or ignition of gasoline that has not been contained properly. Explosions occur when there is the correct mixture of gasoline and air, and this explosive vapor is ignited by a spark. A gas tank could leak at any time and, if the engine is running, ignition is introduced to the situation. Remove any one of these ingredients and you will not have an explosion. Perhaps the best way to prevent an explosion is to keep the gasoline and air mixture from reaching the explosive point. This is accomplished by thoroughly ventilating the areas where explosive mixtures are most likely to form. Gasoline vapors are heavier than air and will seek the lowest parts of the bilge spaces. Consequently, these areas are the ones that must be well ventilated.

Correct Fueling Procedures

In spite of the fact that regulations concerning ventilation of engine and fuel tank spaces are now being clarified and widely enforced, many boats explode every year. Most explosions in inboard powered boats occur shortly after refueling. Refueling is dangerous. But, if certain precautions are carefully observed, many of the potential hazards of refueling can be controlled.

1. Be sure that the boat is moored securely to the fuel float or wharf.

1-6 A Fractured Fuel Line and A Loose Battery Cable Connection.

2. Extinguish all fires aboard the boat. This means cigarettes, cigars, pipes, galley stoves and other appliances which have an open flame. Also, turn off all electric motors which may be running.

3. Close all doors, windows, portlights, hatches or other openings which may allow fumes to enter the bilge spaces of the boat.

4. Remove the gas filler cap and secure it so that it will not fall overboard. Estimate the approximate number of gallons the tank will take. This is a precaution against taking on more gas than your tank should hold. If this should happen, lift a hatch and inspect the bilges immediately to see where the gas is going! Gasoline flowing through the fill pipe could create static electricity. While fueling, it is imperative that you do not allow static electricity to build up and discharge. This can be controlled by grounding the hose nozzle firmly against the fuel pipe intake fitting. A fuel hose should never be left unattended while fuel is flowing through the hose. Even though some nozzles are equipped with shut-off devices which shut off the flow when the tank is full, if the nozzle were to slip out of the fill pipe it could be pouring gasoline over the side or into your boat. While fueling, it is good practice to watch for gasoline fumes which should be coming out of the fuel tank vent pipe. This vent pipe should vent overboard. If you do not see fumes the vent may be plugged and should be cleaned. When the tank is nearly full, gasoline may discharge from the vent, which is not unusual. This gasoline may discolor your paint in addition to being a fire hazard, so it should be washed down as soon as possible.

5. When the tank is full, replace the filler cap and wipe up any gasoline that may have spilled. Then wash down the area thoroughly. Place gasoline soaked rags in a tightly sealed metal container and dispose of them later on shore.

6. Open all portlights, hatches, doors and windows. This should allow any fumes which may have entered the closed areas to escape. If you have a bilge blower, turn it on. Allow the boat to ventilate for at least five minutes. Then check the bilge areas for fumes. Remember, gasoline vapors are heavier than air and will seek the lowest point in the boat. Even though it may appear undignified, stick your nose down in the bilge and check for vapors. Expensive bilge-sniffing devices are fine, but they are not infallible.

7. After you have done all of the above and are satisfied that there are no fumes present, you may start the engine.

Outboard powered boats with portable fuel tanks should not be fueled with the tanks in the boat. Portable fuel tanks should be lifted out of the boat and placed on the wharf to be fueled. Do not attempt to do the job alone. Pass the tank to the attendant on the wharf and, after fueling, have it passed back to you. Don't forget to secure the tank and wipe up and wash down any fuel which may have spilled. If there are any decked-over areas on the boat be certain to ventilate thoroughly for at least five minutes before starting the engine.

To review briefly the safe fueling practices:

1. Boat moored securely.
2. All flames extinguished.
3. All openings closed.
4. Hose nozzle grounded.
5. Wipe up and wash down.
6. Ventilate thoroughly, check for fumes.
7. Start engine.

Unsafe fueling practices, lack of experience, faulty fuel tank installations, and improper wiring of engines and equipment accounted for more than 60% of vessel explosions and fires in cases where the cause of the accident could be determined.

Personal Flotation Devices

All federal, state and local laws require at least one Coast Guard approved personal flotation device aboard and readily available for every person on board the boat. In 1973, 1,734 persons drowned in boating accidents. Of these 47.2% were known to have had personal flotation devices available. 81.7% of the victims did not use the available devices or used them improperly. Of those who drowned, 20.7% were known not to have had personal devices available, and in the case of 32.1% of the victims, it is not known whether or not a personal flotation device was available. Most boatmen comply with the law which requires them to have an adequate number of Coast Guard approved personal flotation devices aboard. How-

ever, in all too many cases these devices were stowed in places where they could not be grabbed quickly when needed. In numerous other instances nobody knew how to use them. Personal flotation devices are effective only when available and properly used. These devices should be treated as though your life may well depend on them.

How to Enjoy Your Boat Safely

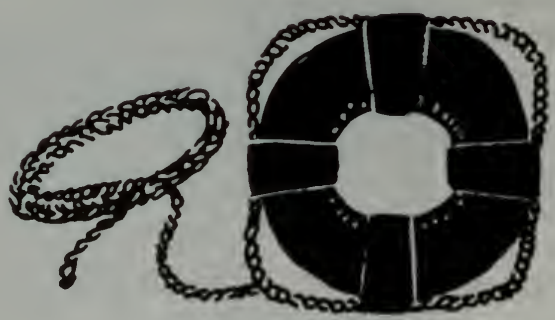
Cruising

Cruising is the most popular form of pleasure boating. Places to go, sights to see, fresh air, relaxation and family fun; these are the ingredients of pleasure cruising. You may cruise along a shore or you may strike out across open waters. Carefree days afloat should not end in tragedy. You can insure this by taking a few simple precautions. Avoid becoming a "statistic" by paying attention to some common-sense rules for safe cruising:

Before shoving off, study your chart for places of shelter in case of bad weather. Be sure that you have enough fuel to get where you intend to go. It's a good idea to have twice as much as you will need, to allow for water conditions which may cause you to use more fuel than anticipated. Be sure that your compass is operating properly and don't place metal objects nearby which could deflect the compass and give you a false heading. Learn to trust your compass. If properly maintained it's a very reliable instrument.

Have plenty of line on board so that you may properly secure the boat wherever your journey may take you. If your boat is wired for 110-volt shore power be sure to have extra extension cords aboard, as you may be required to tie up some distance from a power outlet. It is also advisable to carry a double outlet and spare fuses. If a number of boats are using the same outlet, the voltage to your boat may be low and, as a result, cooking on an electric stove may take longer than expected. If you have an electric refrigerator, low voltage could cause the unit to overheat. Also, be certain that no electric cords are allowed to hang down into the water.

If you cannot find space along a wharf, it may become necessary to anchor overnight. It is best not to



1-7 Ring Buoy.

1-8 Life Vest.

1-9 Cushion.

1-10 Life Preserver.

1-11 Forward Lookout.

attempt this unless weather conditions are good. If possible, put down two anchors, a bow anchor and a stern anchor. This will keep your boat from swinging around with changes in the wind or current, and possibly colliding with another boat. The art of anchoring is discussed in some detail in Chapter Three, BOAT HANDLING. If it is impossible or undesirable to anchor, you may consider asking a fellow boatman whose boat is tied to a wharf if you can tie up to his boat. This is the nautical version of "double parking" and is known as rafting. Several boats can be rafted together. If yours is the boat moored next to the wharf be sure that your mooring lines are in good condition and of a size capable of taking the extra strain which will be placed on them by virtue of the additional boats moored alongside. If you receive permission to raft alongside a boat already moored, be sure to rig enough fenders between the boats to prevent damage to both boats. Do not make a nuisance of yourself by continually crossing the other boat to get to the wharf and, above all, don't keep persons on the boat alongside awake half of the night. If you ask permission to raft and are refused, it's very likely that someone before you forgot these few rules of common courtesy.

What are the hazards of cruising? The most common type of accident while cruising is collision with another vessel. Failure to maintain an efficient forward lookout, or careless and negligent operation on the part of the operator, are the major causes of most collisions. The second most common type is collision with a fixed object. There is little excuse for this type of accident but in 1973, 2,853 vessels collided with other vessels and 599 vessels collided with fixed objects. All told, 684 persons lost their lives in cruising accidents in 1973.

Hunting and Fishing

Hunters and fishermen often use their boats as a form of conveyance rather than for boating enjoyment. Many of them are not aware of the potential dangers of boating and, as a result, it is estimated that in the last few years hunters and fishermen have been involved in approximately 30% of all boating accidents. The Coast Guard Auxiliary is now offering a One-Lesson Course entitled BASIC BOATING FOR HUNTERS AND FISHERMEN. It is hoped that this Course will help to reduce this 30% accident rate. Hunters and fishermen often become so engrossed in their sport that they forget all about the weather. If they happen to notice the weather, they may think they can beat the weather and make it back safely to shore. Many times they find themselves on the sheltered side of an island or in a sheltered cove. When they start their journey back they are surprised by the water conditions on the unsheltered side which must be contended with in order to get back to port. Hunters and fishermen are well advised to wait in sheltered waters until sea conditions improve before attempting to return home. It could save their lives!

Fishermen may get fishing lines tangled around the propeller, rudder, outboard engine or anchor line. In attempting to disengage these lines they often lean too far over the side, with the result that falls overboard are commonplace. To compound this even further, fishing lines sometimes get tangled around a fisherman who has fallen in the water, thus seriously impairing his ability to swim. Most hunters and fishermen carry a sharp sheath knife. This knife should be kept in the sheath at all times when it is not actually being used. This knife could be used to cut the lines and possibly save his life.

A hunter should be careful about standing up in a small boat to shoot. The recoil could knock him overboard. Most high-powered rifles and shotguns recoil considerably and should be fired from a sitting position in a small boat. By using common sense most tragedies might be averted, with the result that more hunting and fishing trips could have a happy ending.

Swimming

Some boatmen use their boats as swimming and diving platforms. A secluded cove with deep, clear water can be most attractive. Swimming and diving are a lot of fun but common sense should not be overlooked. It is usually best to anchor the boat before the swimming party begins. If yours is a shallow draft boat (one which can float in very shallow water), the wind could cause the boat to drift away at a good rate of speed. One person should remain aboard to act as a life guard and to see that the anchor doesn't drag. It is good practice to tie a long line to a life ring and secure the other end to the boat. This should be allowed to drift in the area of the swimmers. Before anyone dives in, the best swimmer aboard should enter the water cautiously to determine the depth as well as inspect the bottom for underwater obstructions. Swimming and sun bathing are as synonymous as sun bathing and sunburn. The sun's rays reflecting off the water, as well as its direct rays, can result in a serious sunburn in a very short time. Keep sunbathing periods shorter than usual and make sure the first aid kit contains ointments for use in such cases.

Racing

Racing is another type of pleasure boating. Racing takes many forms and the fastest boat is not always the winner. Among motor boatmen, the predicted log race is very popular. The object of a predicted log race is accuracy, not speed. The contestant is given a course to run that may include various check points. Before the start of the race the contestant must calculate his "predicted log." The accuracy of his predicted log compared to his actual performance is used to determine the winner. An observer is assigned to each contestant's boat and his job is to see that no time-measuring instruments are used during the race. He is the official timekeeper. The contestant must calculate in advance the distance to be traveled, compass headings to be held, speed to be run (taking into consideration water conditions and legal speed limits), and any other conditions which may be encountered. The contestant must then predict the exact time it will take him to run the course as well as the exact time to each check point. At the finish of the race the actual elapsed time is recorded and the predicted time is divided into the error to give a percentage of error. The lowest percentage of error is the winner. Thus you can see that a boat running at a slower speed may have a larger time error and end up with a lower percentage of error. Sounds easy, doesn't it? Try it! A predicted log race is a great leveler. Winners smile quietly while losers loudly proclaim that the winners were "just lucky." Occasionally an inept seaman may have all of his mistakes cancel each other out and emerge the winner, but this is a rarity. Those who can consistently win or place in predicted log races do so because they have taken into consideration all of the factors involved. These factors include the vessel's weight, the condition of her bottom (marine growth), anticipated wind and current conditions, leeway, the time involved in making turns and many other considerations. When you can do well in predicted log races, you can consider yourself proficient in the art of seamanship. This Boating Safety and Seamanship Course will help to give you the basic knowledge needed to take part in such contests, but from there on the application of that knowledge is entirely up to you.

Among sailboats, speed racing is the favorite. Sail boats engage in two different types of races. One is a closed-course race around buoys or markers and the other is an open-course race from one point to another. The longer open-course race is usually engaged in by any type of cruising class boat, while the closed-course race is restricted to boats of the same class. Class is determined by the measurements of a boat, taking into consideration such factors as the sail area, draft, beam, overall length and length at the water line. Each boat in its class is assigned a handicap and this handicap is applied to the time the boat makes in a race. Rules for sail boat racing may be obtained from the North American Yacht Racing Union at 37 West 44th Street, New York,

N. Y. 10036. This is the American representative to the International Yacht Racing Union which governs sail boat racing throughout the world.

There are also races for power boats where the fastest speed wins. Maximum horsepower or engine cubic capacity is usually established for each race. Rules for these races may be obtained from the American Power Boat Association, 2534 St. Aubin Street, Detroit, Michigan, 48207.

Some races cannot be classed as power or sail because they involve what is known as "slave labor." Rowboat races are popular in many parts of country, and shell racing may be found on rivers, lakes and sheltered waters. These are endurance races in the sense that they test physical strength and muscular co-ordination. For the average American boatman these are best enjoyed in the role of a spectator rather than that of a participant!

Water Skiing

Water skiing is increasing in popularity in all parts of the country. Skiers skim over the water at speeds of 25 knots and upwards. Two skis, slalom, backwards, no hands—real fun! How safe? It can be very safe if the skier wears a Coast Guard approved personal flotation device and the boat operator knows what he is doing. Here are a few pointers which will insure your safety without spoiling your fun:

1. Install a wide-angle, rear-view mirror or take along a second person in the boat to watch the skier. In this way an efficient watch can be maintained both fore and aft. Some states require the mirror or an observer as a matter of law.

2. Don't tow a skier in heavily traveled or restricted waters such as anchorages, swimming or fishing areas, narrow winding channels or around piers, floats or buoys.

3. Make sure that the skier is wearing a Coast Guard approved personal flotation device. If he tumbles, the boat should come about and approach him from the lee side.

4. Stop the engine before taking the skier on board.

5. While taking the skier on board be careful not to swamp the boat. In smaller craft it is usually safer to take a person aboard over the stern.

The following set of hand signals is recommended by the American Water Ski Association:

FASTER — Palm pointing upward.

SLOWER — Palm pointing downward.

SPEED O. K. — Arm upraised with thumb and forefinger forming a circle.

RIGHT TURN — Arm outstretched pointing to the right.

LEFT TURN — Arm outstretched pointing to the left.

BACK TO DROP-OFF AREA — Arm at 45 degree angle from body pointing down to water and swinging.

CUT MOTOR — Finger drawn across the throat.

STOP — Hand up, palm forward, policeman style.

SKIER O. K. AFTER FALL — Hands clenched overhead.

PICK ME UP, OR FALLEN SKIER — WATCH OUT — One ski extended vertically out of the water.

(*See page 12 for Illustration*)

Skin Diving

A relatively new flag is appearing on our waters. It has a red-orange background with a white diagonal stripe from corner to corner. This is the divers' flag. When you see it flying from a boat, or from a float, do not approach too closely or attempt to pass between the flag and the nearby shore. This flag indicates that there are divers down in the area and it requests you to keep clear. If you have ever seen a person who has been cut by a boat's propeller, you will not easily forget it.

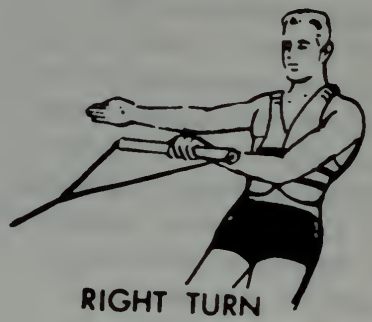
1-12 Beware—Diving in Area.

1-13 Water Ski Hand Signals

FASTER

SLOWER

SPEED O.K.



RIGHT TURN

LEFT TURN

BACK TO DROP-OFF AREA

CUT MOTOR

STOP

SKIER O.K. AFTER FALL

PICK ME UP OR
FALLEN SKIER — WATCH OUT

Proper Selection of a Boat

The key to boating enjoyment is to have a boat that is exactly right for you and your family, and the kind of boating you intend to do. Another thing to consider is the water conditions in your boating area. A boat that is adequate for a small inland lake might not be safe on an unsheltered body of water. A boat that does not have sleeping or cooking facilities would not make a good cruising boat. A boat designed for a top speed of 18 knots will not be a good ski boat. A family of eight is not very safe in a 14-foot boat.

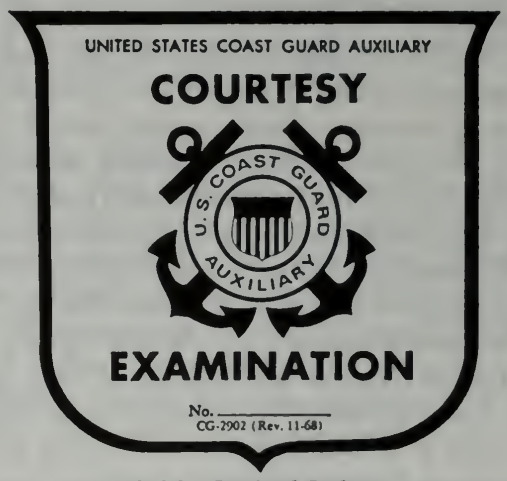
A boat should be purchased because it fits your needs and not because it is offered at a bargain price. Be sure that it is large enough to accommodate your family and guests. Many boats are equipped with a capacity plate which will indicate the recommended size of the engine and the number of pounds the craft is designed to carry safely. To exceed the recommendations of the capacity plate is to be asking for trouble. Overpowering an outboard boat with an engine that is obviously too large and too heavy will have the effect of reducing freeboard at the engine well and your boat could be swamped by taking water over the stern if stopped quickly. The stern wave could roll right in. If you are in doubt concerning the condition of a boat that you are thinking of buying, the best thing to do is to employ the services of a qualified marine surveyor. The surveyor will give you a complete report on the condition of the boat. He will look for things like rot, cracked or broken frames, split planking and mechanical defects. A good survey could save many dollars in the long run.

Practical Hints for Safe Boating

Keep in mind at all times that everything that is done and everything that is used on a boat affects the safety, not only of those aboard, but also those nearby.

If your boat is small, remember that you must board it by stepping into the center of the bottom, not onto a gunwale or seat. Never jump into a boat. Don't stand up in a small boat without hanging on, and don't rock the boat just to show off. Use a safety chain or cable on the outboard engine. Engines have been known to come loose occasionally.

Get a Courtesy Examination. To be doubly sure that your boat and equipment meet the minimum safety requirements, ask for a free Coast Guard Auxiliary Courtesy Examination. The Auxiliarist will examine your boat for compliance with federal regulations and certain additional recommendations which the Auxiliary considers desirable for your safety. If your boat passes the Courtesy Examination, a current Courtesy Examination Decal will be placed on the boat. Unless you are obviously violating the law, Coast Guard Boating Safety Detachments will not normally board any vessel displaying a current decal. If your boat does not pass, a report will be given to you indicating the areas in which your boat or equipment was found to be deficient. No record of this examination is made nor kept by the Auxiliarist and no report is made to any law enforcement agency including the Coast Guard.



1-14 Seal of Safety.

Know your boat. Know what it can do and what it cannot do, and how it will handle in all kinds of weather. Don't load more weight aboard than recommended by the capacity plate. The ideal boat should have positive buoyancy. This means that it should float even if filled with water or capsized.

Leave a float plan with a friend or relative before departing on a boating outing. Don't simply hand it to a bystander on the wharf. Be sure that you leave it with someone who will miss you if you do not return on time. A float plan should include the following information: (a) where you intend to cruise; (b) a description of your boat and your state registration number; (c) communication equipment aboard and radio call sign if you have one; (d) the

names of all persons on board; (e) safety equipment carried; (f) the estimated time of arrival at your destination or return; and (g) your alternate plans in the event of an emergency or in case of bad weather.

Be defensive against causes of fires and explosions. Three steps are necessary to reduce the chance of flammable vapors collecting in your boat: (a) have a safe fuel system aboard and maintain it in good condition; (b) observe all safety precautions in handling volatile fuels; and (c) have a good ventilation system to conduct fresh air into each fuel tank and engine compartment to remove vapors from the bilges to the open atmosphere. Three of the federal requirements for motor boats (flame arresters, fire extinguishers and adequate ventilation) are intended to minimize the danger of fire and explosion. This is sufficient evidence of the seriousness of the fire and explosion hazards in engine and fuel tank compartments. The galley is another potential fire hazard. Electric, alcohol, kerosene, butane, coal and wood burning cooking appliances are recommended types for use on boats. Gasoline stoves should never be used. The stove should be fastened securely in place. The counter top and bulkheads (vertical partitions) around the stove should be protected with a fire-proof material. Curtains and draperies which are near the stove should be of flame retardant material and should be tied back before lighting the stove. Do not place a fire extinguisher on a bulkhead in such a position that you must reach through a fire to get to it. Mount it nearby where it can be easily grasped. Fire extinguishers should be checked and serviced regularly, and as soon as possible after use.

Be sure to provide personal flotation devices for all hands aboard. These should be Coast Guard approved and kept readily available and in good condition. This applies to all boats, regardless of size. Prudent boatmen generally carry more personal flotation devices than they expect to need. It is better to have a few extra devices aboard and not need them than to need them and not have them. Personal flotation devices should be worn by all hands when boating conditions are hazardous, and by children and non-swimmers at all times while under way. In addition to the equipment required by law you should also have a good first aid kit, a good local chart, a flash light, distress flares, a paddle or oars, extra shear pins, a bailer or bucket, an extra anchor and plenty of anchor line, mooring lines, fenders, a good tool kit, a compass, reserve fuel and extra spark plugs, emergency water and emergency food rations, and a transistor radio capable of receiving on the marine band. These would be considered the minimum requirements and, if you give the matter some thought, you will think of many more items you would want to have along.

Know and obey state and federal boating laws. Nautical traffic laws are known as RULES OF THE ROAD. These rules differ according to where you do your boating. You should become conversant with the set of rules which applies to your local waters and you should abide by them.

Load your boat properly. Large steamships have capsized when all passengers rushed to one side. The load must be distributed properly if the boat is to handle well. Watch your freeboard. Many small boats have swamped or capsized when they were loaded to the point where they had insufficient freeboard.

Pay attention to your boat handling. High speed and sharp turns are frequent causes of accidents on water as well as on shore. Keep an eye on your wake. Even the wake of a small outboard boat can cause damage to others. You could be held legally liable for any damage caused by your wake. Keep away from swimmers and divers. Slow down when passing fishing boats. When passing sailboats, don't pass between the sailboat and the wind. Pass to leeward (the downwind side). Keep well clear of large vessels and tows. Their wakes are dangerous to small craft. Do not allow passengers to ride on the bow deck or on the gunwales. Any sudden motion of the boat could cause them to fall overboard.

Carry two anchors with plenty of line. When anchoring, lower the anchor over the side hand over hand—don't throw it. Anchor well clear of navigable channels and don't forget to light your anchor light at night. Anchor lights will be discussed in the chapter on Rules of the Road.

Respect the weather. Listen to marine forecasts and heed weather warnings. Even rivers can get rough, particularly if a strong wind blows upstream. In bad weather head for the nearest harbor or find

a spot in the shelter of an island and wait until the worst is over.

Keep a good lookout. Failure to do so is the cause of most collisions. Your primary consideration should be the area ahead and on the right side of your boat. Vessels approaching from the right (starboard) side have the right of way over your boat and you should keep clear of them. This will be discussed in the chapter on RULES OF THE ROAD. It's a good idea to look all around the horizon occasionally to see what is going on around you.

Keep clear of fixed obstructions. When passing under a bridge keep well away from the piers. Portions of caissons and pilings used in the construction of the bridge may be just under the surface of the water. Also, on large rivers, the water around bridges can be turbulent and dangerous. Keep clear of breakwaters and jetties. If your engine should fail while near these obstructions your boat could drift into them before you could get an anchor down.

Watch out for overhead power lines. Fire aboard, serious injury and even death can suddenly strike if the mast or radio antenna of your boat touches an overhead electric wire. Always keep a sharp lookout for aerial power lines. Watch for them across shorelines, coves, rivers and inlets — at marinas and launching ramps.

Be familiar with emergency procedures. Familiarize your crew members with them. Without frightening them, you could conduct a lifesaving device drill. Show them how to adjust the devices so that they will be most effective if needed. It's best not to talk about capsizing since this may frighten your crew, but you should have your plans clearly in mind in the unlikely event that this might happen. Your boat will most likely remain afloat and you should see to it that nobody attempts to swim for shore. Remember, the chance of being located by a search plane or boat are far greater if all hands stay with the boat and hang on.

Keep the boat in good condition. Make necessary repairs as required and check all safety equipment regularly.

And finally, don't operate a boat while intoxicated. An intoxicated boat operator is just as deadly as an intoxicated motorist. Save the libations for the time when the anchors are down and securely set, or after you have returned safely to your slip. If you must drive home, save them until you get there. Don't become another statistic.

Boating safety is a state of mind. To the safe boatman, safety is the first consideration. Think and practice safety all the time and soon it will become second nature to you. The peace of mind that comes from owning a safe, well equipped boat, and knowing the proper way to operate it safely, will make your boating experiences pleasant and relaxing Only then will you join the vast majority of boating enthusiasts who say with conviction,

"SAFE BOATING IS FUN."

CHAPTER 2

the Sailors' Language

Introduction

The sailors' language has been developed over the years to the extent that it should be understood if one is to fully enjoy the sport of pleasure boating. You will soon discover that a word or phrase means one thing to a "land lubber," and quite another thing to a boatman. For example, most of us would agree that descending from one level to another is going downstairs, and is accomplished by means of stairs or steps. To a boatman, it is going below using a ladder.

The terms defined in this chapter should gradually become a part of your boating vocabulary. As your boating knowledge increases, you will find yourself using many of these terms to describe parts of your boat and its equipment. These terms may also be used when giving instructions to others aboard your boat. The first few times that you use a nautical term, explain it carefully so that your crew members will know what the term means.

Basic Terminology

Listed below are some of the nautical terms that you should learn at this time so that you may fully understand this chapter and those to follow. They are common, everyday terms as far as boating is concerned. Each has a specific meaning that will be understood by other boatmen.

The following terms describe parts of a vessel:

HULL—The body of a vessel exclusive of superstructure such as the cabin, flying bridge, masts, etc.

BOW—The forward part of a vessel.

STERN—The after part of a vessel.

TRANSOM—Planking across the stern of a vessel.

BOTTOM—The surface of the hull below the waterline.

CHINE—On a flat or vee-bottom boat, the fore-and-aft line formed by the intersection of the side and the bottom.

KEEL—The principal framing member of a vessel, running fore-and-aft the entire length and supporting the frames.

FRAMES (Ribs)—The curved framing members attached to the keel.

BEAMS—Strong timbers stretching across the vessel to support the decks.

DECK—The planked floor of a vessel, resting upon the beams.

GUNWALE—The top edge of the hull.

TOPSIDES—The outer surface of the hull from the waterline to the gunwale.

BILGES—The lowest internal spaces within a vessel's hull.

BULKHEAD—A vertical partition aboard a vessel.

COCKPIT—A space or well, sunken below the gunwale line, usually in the after portion of the vessel.

PORTSIDE—The left hand side of a vessel facing forward.

STARBOARD SIDE—The right hand side of a vessel facing forward.

PORTHOLES—Openings in the vessel's sides for admission of light and air.

SCUPPERS—Overboard drain holes on the deck.

HATCH—An opening in the deck to afford entry to spaces below.

HEAD—The vessel's toilet compartment.

GALLEY—The area aboard a vessel where cooking is done.

LADDER—Stairs or steps aboard a vessel.

WINDWARD SIDE—The side of the vessel exposed to the wind.

LEEWARD SIDE—The side of the vessel sheltered from the wind.

Terms that describe fittings and other equipment are:

LINE—Rope that has been put to use aboard a vessel.

CLEAT—An anvil-shaped deck fitting to which lines are secured.

CHOCK—A deck fitting through which lines are passed.

RUDDER—An underwater vertical blade which can be pivoted to steer the vessel.

HELM—The mechanism by which the vessel is steered, including the rudder, wheel, etc.

FENDERS—Pneumatic, rope or other devices hung over the side of the vessel to protect it from chafing.

FID—A tapered pin, used to open the strands of rope for splicing.

MARLINSPIKE—A pointed iron tool, used to open the strands of rope or wire rope for splicing.

Some of the fittings and equipment found on sailboats should be of interest. A few are mentioned here. Chapter 10, which has as its subject matter "Sailing", goes into much more detail.

MAST—A spar set upright from the deck to support rigging and sails.

SHROUDS—Lines on each side of a vessel, reaching from the masthead to the vessel's sides, to support the mast.

STAYS—Large lines used to support masts, leading from the head of one mast to another, or to the deck. Those which lead forward are called forestays. Those which lead aft are called backstays.

HALYARDS—Lines used for hoisting and lowering sails.

BOOM—A spar used to extend the foot of a fore-and-aft sail.

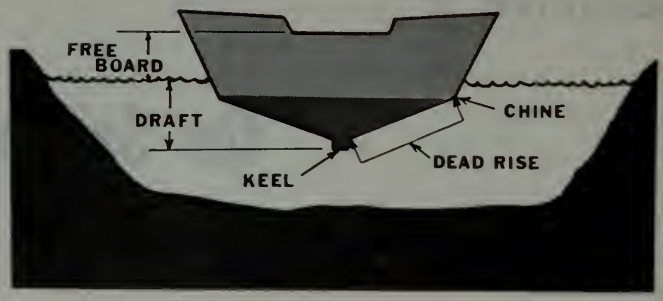
BOWSPRIT—A large, strong spar extending from the bow of a vessel.

JIB—A triangular sail set on a stay, forward.

MAIN SAIL—The principal sail.

FORE SAIL—A sail carried forward of the main sail.

MIZZEN SAIL—Usually the aftermost sail if this is not the main sail.



2-2 Parts of a Boat

The dimensions of a vessel are:

BEAM—The breadth of a boat at its widest point.

DRAFT—The vertical distance from the waterline to the lowest part of the vessel beneath the water.

FREEBOARD—The minimum vertical distance from the waterline to the gunwale.

LENGTH—The distance from the bow to the stern, measured along the vessel's center line, exclusive of bowsprits and other projections.

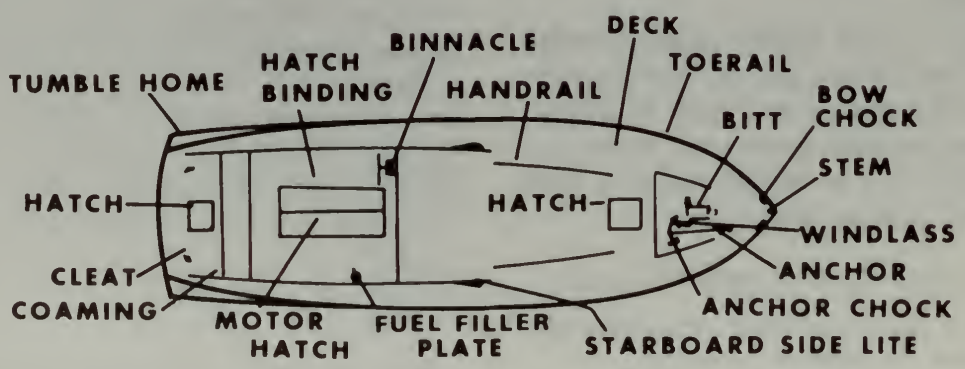
SHEER—The longitudinal upward or downward curve of the deck fore-and-aft.

The following terms describe directions or locations of items aboard the vessel or closely alongside:

ABAFT—Toward the stern.

AFT—Near the stern.

ALOFT—Above the deck.



2-1 Topside Nomenclature

Amidships—the center of the boat—with reference to her length or to her breadth.

Ahead—In the direction of the bow.

Astern—In the direction of the stern.

Athwartships—Across the line of the vessel's keel.

Below—Beneath or under the deck.

Fore-and-aft—Lengthwise with the vessel's keel. The opposite to athwartships.

Close Aboard—Alongside, close to the hull.

Inboard—Toward the centerline of a vessel.

Outboard—Away from the centerline of a vessel.

Windward—Toward the wind.

Leeward—The direction opposite that from which the wind blows; downwind.

The following terms describe relative directions as viewed *from* a vessel *toward* an object which is *not aboard* the vessel:

Ahead (Dead Ahead)—In the direction of the vessel's fore-and-aft center line, forward of the bow.

Abeam—In a direction at right angles to the vessel's keel, on either side.

Broad on the Bow—In a direction half-way from ahead to abeam of the vessel, on either side.

Astern (Dead Astern)—In the direction of the vessel's fore-and-aft center line, behind the stern.

Broad on the Quarter—In a direction half-way from abeam to astern of the vessel, on either side.

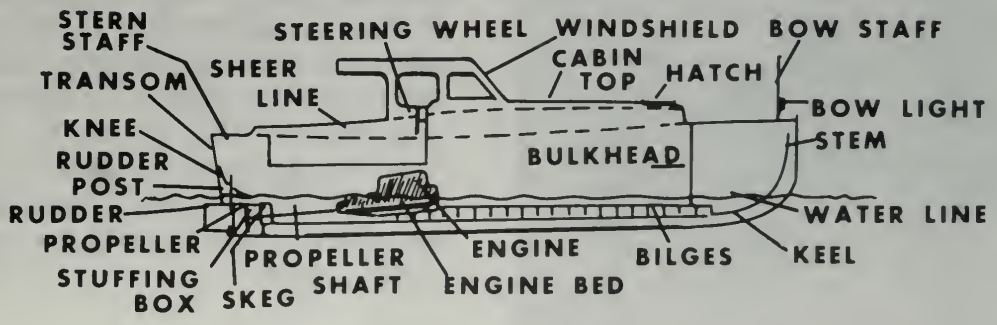
Types of Motorboats

If you are shopping for your first boat, you will find that there are an infinite number of models and sizes on the market. Each has been developed over the years to meet a specific need. Some are adapted to suit specific boating activites and are not suitable for others. So when you select a boat, be sure that it will suit your purposes.

Skiffs are truly the utility boats for the boatman. They are popular because of their simplicity and durability. Skiffs are flat-bottomed with either straight or slightly flared sides. A skiff is easy to row and may be fitted with a small outboard engine. Because it is flat-bottomed, a skiff is ideal for a hunter or fisherman to operate on protected shallow water.

Prams are similar to skiffs except that they are smaller and the bows are squared-off instead of being pointed. They are constructed with either round or shallow "vee" bottoms. Although quite small, a pram is more stable and easier to tow than a skiff. It is designed primarily for rowing but will perform reasonably well with a small outboard engine.

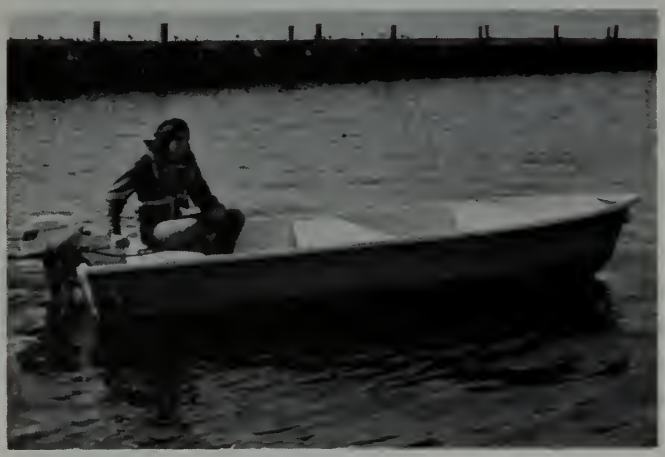
Dinghies are small boats with rounded bows, round bottoms and wide beams for their short length. Like prams, dinghies are intended for rowing but may be fitted with small outboard engines. Dinghies are used principally as tenders carried aboard larger craft. Because of their rounded bot-



2-3 Sectional Nomenclature.

toms, dinghies are remarkably unstable. One should be careful when entering a dinghy to step in the center of the bottom and not on a gunwale.

Utility outboards are favored by boatmen who rely on outboard engines for power. They are specifically designed for outboard propulsion and consequently are difficult to row. Most utilities are completely open, though some have decked-over bows. They may be powered by engines up to 45 hp, depending on their size and design.



2-4 Utility Outboard

Runabouts are more sporty craft than utility outboards. Most runabouts have decked-over bows and are intended for general use such as cruising, water skiing and fishing. Most are powered by outboard engines although some runabouts have inboard engines.

2-5 Outboard Runabout

Cruisers are built in a wide variety of shapes and sizes depending on their intended use. Those designed for extended cruising have large cabins and small cockpit spaces, while those used primarily for short trips have smaller accommodation areas and larger open cockpits. Small cruisers are designed for occasional overnight use; large cruisers are used by some as houseboats. The cruiser "type" is described by the configuration of the hull and superstructure—raised deck, flush deck, trunk cabin, sedan or flying bridge. Power can be inboard or outboard, depending on the size of the boat.

2-6 Cabin Cruiser

A *houseboat* is a popular modification of the cruiser, and has mushroomed in the popularity polls. Traditionally, the houseboat was boxy, comfortable and slow. For a person who wished to get away from it all to enjoy his leisure time on a quiet backwater, the houseboat provided the answer. Until the early sixties the houseboat lacked dash and appeal. Today's modern houseboat offers all the conveniences of home. Some have sufficient power and speed to tow water skiers. Design and appearance-wise, modern houseboats leave nothing to be desired. With the advent of fiberglass and modern hull adaptations based on the catamaran (twin hull) design, some of the larger houseboats are capable of taking heavy seas as safely as any offshore cruiser.

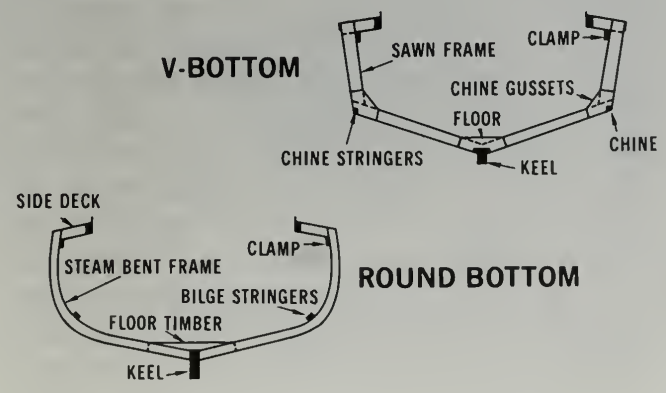
Hull Design

There are two basic types of boat hulls — displacement and planing. The displacement hull

displaces a volume of water equal to the weight of the boat regardless of the boat's speed through the water. A displacement boat is limited by its design in its top speed. In a displacement hull, there is a direct relationship between the shape of the hull, the length of the boat's waterline and hull speed. A displacement hull vessel should not be forced to attain a speed greater than that for which it was designed. Adding more horsepower to increase speed usually results in reducing the handling characteristics of the boat. Displacement hulls are found on most larger sailboats and ocean-going powerboats, as well as rowboats, canoes, dinghies and prams.

At slow speeds the planing-type hull displaces water in the same manner as a displacement hull. As speed is increased, the hull design imparts a lifting effect. When sufficient speed is attained, the hull comes up "onto the plane." This planing effect decreases the displacement and makes practically unlimited speeds possible, dependent on horsepower only. To help a planing boat achieve a greater speed, light, strong materials are used in its construction.

While there are no hard and fast rules, displacement boats are constructed usually with round bottoms or deep vees, while planing boats are built mostly with shallow vees, flat or channel bottoms. But it should be pointed out that marine architects will adapt all types of construction to obtain the desired results in any particular boat design.



2-7 Boat Construction

Construction of boats

The types of materials used in the construction of boats have changed considerably in the past few years. Until quite recently, most pleasure craft were constructed of wood only. Now, many boats are built of fiberglass, plastics, aluminum, steel and ferro-cement. Even wood construction has changed in some instances. Wooden vessels used to be planked; now they are made also of plywood and laminated wood strips.

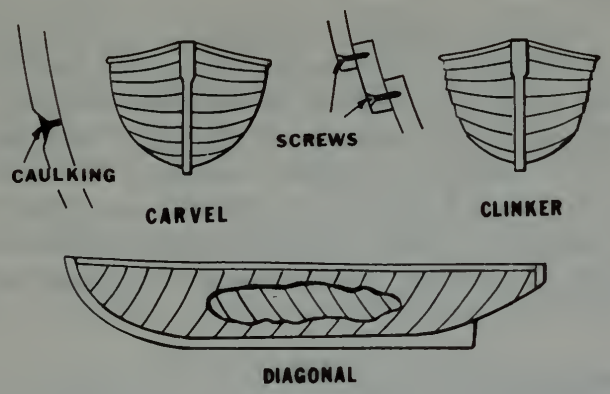
Wooden Construction

In wooden construction the most popular materials used for keels and frames are Douglas fir, white oak and southern pine. Cypress, cedar, mahogany and redwood are most often used for planking. Sitka spruce, hemlock, white pine and yellow poplar may be used where lightness and strength are desired, but where decay resistance is relatively unimportant. Fastenings used on wood hulls should be of non-corrosive material. Whenever wood is used for construction, it should be treated thoroughly with a decay resistant compound. Closed compartments should be kept clean, dry and well ventilated to prevent dry-rot. Periodic bottom painting is required to resist the action of marine borers. Some larger boats are built with wooden sheathing separated from the planking by a layer of felt, impregnated with a compound to discourage marine borers.

The use of marine-grade plywood has become popular for moderate sized hulls of hard-chine construction. Also, one-piece moulded plywood or laminated construction is often found in smaller hulls.

There are several types of wood plank-hull construction. The planks, or strakes, of a carvel-built hull lie alongside each other without overlapping. Each strake is fastened directly to the frames. Frames may be either bent or sawed. The strakes are fitted so that they touch each other along the inner edge. The edges of each strake are beveled toward the outside surface. This forms a V-shaped groove into which caulking and seam compound is inserted.

In lap-strake construction, the planks overlap at the edges like clapboarding on a house. Rivets are



2-8 Basic Wood Plank Construction

generally used for fastenings. These rivets pass through the upper overlapping strake, the lower overlapped strake and then the frame. In this type of construction the frames are usually of the bent type. Seams are left unfilled, or various compounds are used between the strakes. The lap-strake hull makes a very light, strong boat. The exposed edges of each strake resist the tendency for the boat to roll just as bilge keels do on larger craft.

Diagonal-built hulls have two layers of planking. The first is laid tending forward at a 45 degree angle to the keel. The second layer is laid tending aft at right angles to the first. This type of construction requires little framing and still makes a very strong hull.

Fiberglass Construction

Fiberglass has become an important building material for boats of all sizes. It is strong, impact and chafe resistant, weathers well, and is watertight. Fiberglass, in finished form, is a type of reinforced plastic. The plastic materials used are polyester and epoxy resins. Most commonly, layers of glass cloth and woven roving are bonded together by resin in a mold over a form. Nearly all fiberglass boats have the desired color mixed in with the gel-coat. However, the color could fade as time passes, and it might become necessary to paint the boat. Fiberglass hulls do not provide protection from marine growth and, therefore, must be given a coat of antifouling bottom paint to keep the bottom clean.

One advantage of fiberglass construction is that it does not require great amounts of longitudinal and transverse structural members. To be sure, the hull must be given some strengthening, but the one-piece skin of the hull eliminates most of the need for frames and stringers. A fiberglass hull that has been built carefully is an extremely tough, resilient and watertight structure. It will survive a great deal of punishment but should not be abused. Minor repairs are made easily, though large holes present difficulty for one who is not experienced with the material.

Aluminum Construction

Aluminum is becoming widely used for hulls and also for superstructures. It is light, strong, fashioned with greater ease than steel, and (when anodized) is highly corrosion resistant. Aluminum hulls are built in one of two ways. Sheets are bent to the desired shape or they are pressed into shape by hydraulic presses. The resulting plates are welded together or, if riveted, the seams are filled with synthetic caulking compound. "5000" series marine aluminum alloy is extremely corrosion resistant, even in salt water. However, salt water will attack the surface of other aluminums, so it helps to give the hull a coat of paint. Aluminum causes the greatest amount of trouble when it comes in contact with other metals under water. When used adjoining a dissimilar metal, care must be taken to insulate it in order to prevent galvanic action or electrolysis.

The underwater body of a boat and its fittings are usually protected against galvanic action by placing magnesium or zinc blocks in the vicinity of the screws and rudder. These blocks are called "zincs" by most boatowners and are attached frequently to the rudder and shaft strut. Often they take the form of collars which are attached to the rudder posts or propeller shafts. Boats should be outfitted with polarity indication systems if they are apt to be troubled by galvanic action. Through-hull fittings should be grounded properly. These precautions are particularly important if shore-side electrical power is used when the boat is moored alongside a wharf or in a slip. Outboard engines use dissimilar metals such as bronze, brass and aluminum. So it's a good idea to attach "zincs" or raise the engine out of salt water when it is not in

use. These precautions may retard corrosion for several years.

Ferro-cement Construction

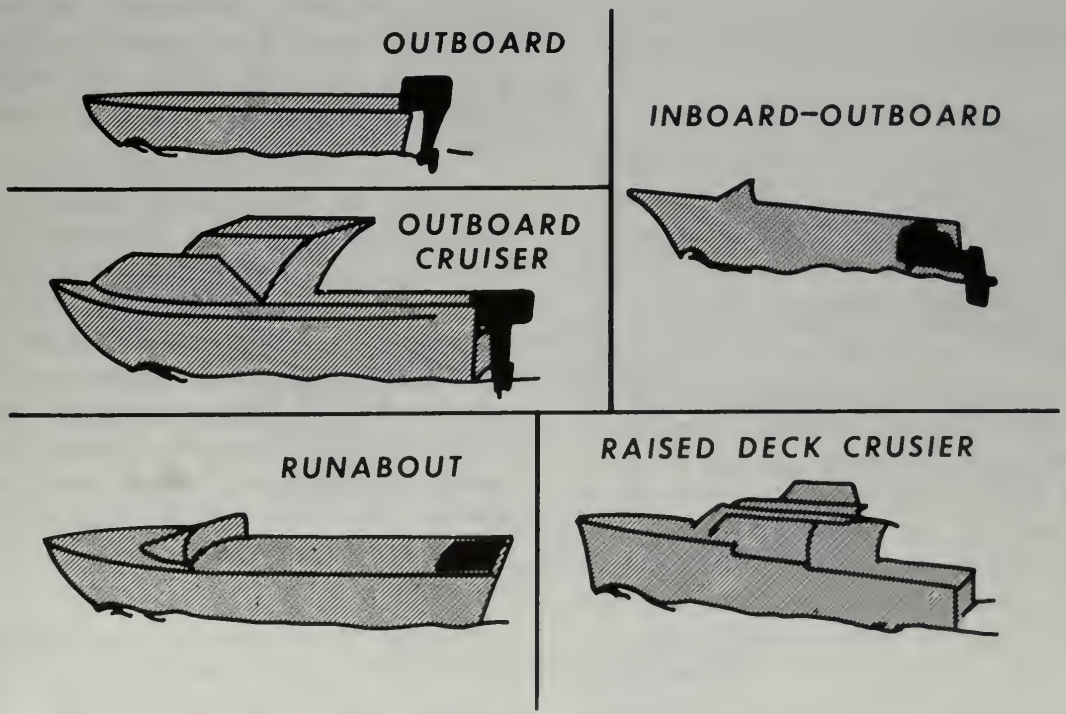
The development of cement as a boat building material is not new. In the days of World War I, cement was used to build ships. The use of ferro-cement in the construction of boats 40 ft. or more really saw the light of day in Australia. The technique spread to Britain in the forties, then to Canada, and recently to the United States. The ferro-cement boat is basically a frame of steel mesh plastered with cement and sand. In terms of strength and durability, the ferro-cement boats must be placed at or near the head of the list. It has been shown that ferro-cement boats will stand the most outrageous mishandling. They can be repaired easily and economically even when they have sustained collision damage that would have sunk a conventional boat.

One of the most interesting facts about ferro-cement hulls is that they can be made to weigh less than comparable wooden counterparts. In terms of cost, the ferro-cement hull is considerably less expensive than a comparable hull of conventional materials. It is possible that the advent of ferro-cement in boat-building will mean that the boat owner of the future will receive much more for his money. Fortunately, the ferro-cement boat will equal or exceed the best conventional boats in terms of appearance.

The one limitation of ferro-cement is that it probably will not be used in boats of less than 40 ft. in length. It is not practical as a replacement for fiberglass in the smaller boats being mass produced today. On smaller craft it is still comparatively heavy. This is the one exception to the statement that ferro-cement boats are lighter than boats of conventional materials.

Propulsion

There are various types of marine engines on the market today. Most engine systems are designed for a particular type of craft. Matching the wrong engine to a boat might be disastrous. When you buy an engine, the recommendations of the manufacturer concerning propulsion requirements should be followed. Keep in mind that if the horsepower of the engine is doubled, it does not necessarily follow that the speed of the boat will be doubled. The increased weight of the larger engine, plus the



2-9 Types of Boats

weight of the extra fuel and accessories that will be required to accommodate the larger engine, may cancel out much of the anticipated extra speed. Also, it may destroy the trim of the boat.

Inboard marine engines manufactured today are either gasoline or diesel piston types. Most operate on the 4-stroke cycle. A diesel engine usually weighs more than a comparable gasoline engine, but its economy of operation and comparative safety are appealing to many boatmen. An inboard engine is mounted within the hull on an engine bed, and transmits power to the propeller by way of a shaft extending through the hull. Horsepower ratings for these engines begin at approximately 15 hp.

The outboard engine is basically a portable gasoline fueled engine with its own integral drive shaft and propeller. The outboard engine is attached to the boat's transom, and turns on a pivot to change the direction of the boat. An outboard engine operates on either the two or four stroke cycle, and horsepower ratings vary from a fraction of one horsepower to well over a hundred "horses." Outboard engines find favor among many boatmen because of the engines' portability, compactness and relative ease of repair. The horsepower capacity plate should indicate the recommended engine horsepower for the boat. If your boat does not have one of these plates, you would be well advised to consult the dealer and be guided by his recommendations.

The inboard-outboard installation combines the best features of both inboard and outboard engines. The engine is mounted inside the hull and connects through the transom to the propeller assembly. This assembly has all the characteristics of the lower portion of an outboard engine shaft.

The tunnel drive has recently reappeared on the boating scene in small boats, although the idea of enclosing the propeller in a tunnel has been developed for many years. The boat hull has a tunnel formed in the bottom toward the stern. The engine is set low in the hull and practically horizontal in a position forward of the tunnel, with the shaft projecting through the hull and out into the tunnel. The advantages of such an installation are worthy of mention. The propeller is protected by the tunnel so that it is possible to beach the boat as easily as an outboard or in-out propelled boat. The tunnel arrangement permits the boat to be operated safely in very shallow water. It has a conventional installation — engine, transmission, shaft and propeller. The cost of such a conventional installation is considerably less than that of a normal in-out installation.

The jet drive is another system of propulsion. It is an inboard engine coupled to a high-speed water pump. The water being pumped out at the stern propels the boat. The direction of travel is controlled by the direction of the jet, hence the need for a rudder is eliminated. The chief advantage of the jet drive is its ability to operate in shallow water. The bottom of the hull has nothing protruding from it. But it does have one disadvantage. All types of material can be sucked into the jet pump. Most can be discharged safely but certain materials can cause a total blockage, and the pump will have to be taken apart to be cleared. Clearing a jet drive water pump is not as simple as cutting a piece of rope from a fouled propeller. It will most likely require the services of a professional.

The Boat Trailer

Picking the Right Trailer for Your Boat

The first boat trailers used by our boating forefathers were heavy, cumbersome and crude. Often they were cast-off farm wagons or adaptations of automobile axles and wheels, with bolted steel or wooden beds. Boats were lifted by brute force and placed on the trailers.

Getting the boats off the trailers and into the water was also a problem. In the early days, boat launching ramps were few and far between. With the gradual development of boats and boating areas, more launching ramps were constructed. The boating industry was quick to realize the potential of small boating and began producing boat trailers. The earliest boat trailers were custom made to the owners' specifications. This was costly and production was on a small scale. Soon several firms began producing trailers for small boats on a production line basis.

Through "trial and error" it was discovered that boat trailers needed to be light and well balanced so they would "track" properly behind the towing vehicle. They needed to be constructed substan-

tially, in order to withstand the strain of high speed travel. They needed adequate support for the hull, as well as tiedowns, safety chains, tail lights and turn signals. Watertight seals for wheel bearings, winches, and manual or electric brakes were later developments.

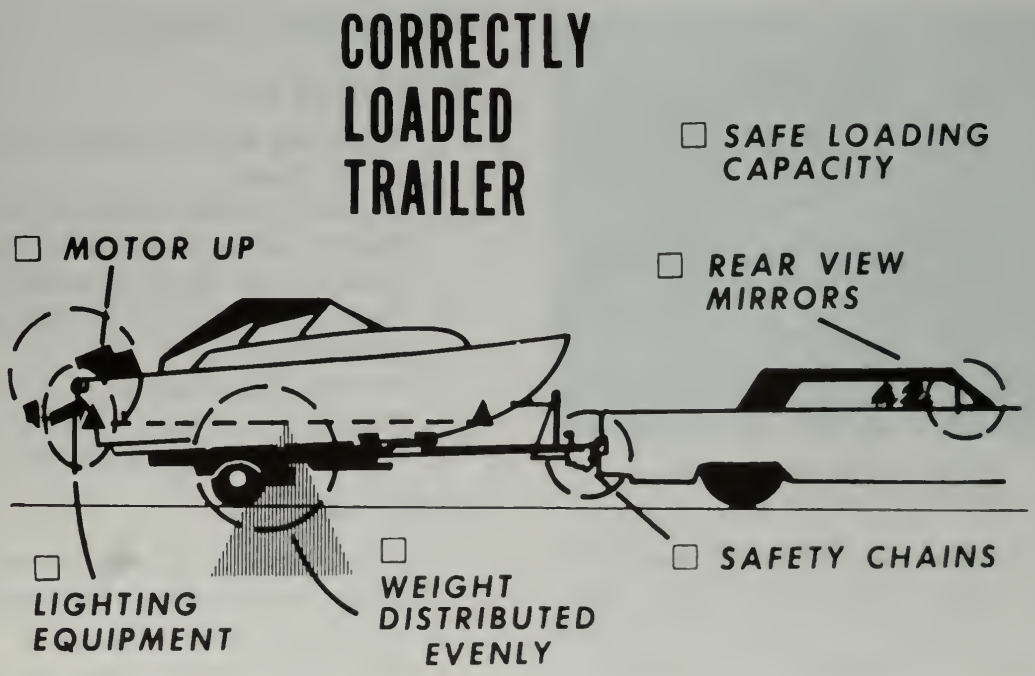
Special tires and "A" frame trailers were developed to make launchings easier. Some boat trailer manufacturers began using aluminum in place of steel. This made trailers considerably lighter, and some boatmen believe they are easier to maintain.

Normally, the length of the boat determines the length of the trailer. The beam (width) determines the width of the trailer. The boat should fit snugly on the trailer when it is cranked up to the winch support. There should be proper support for the boat's bottom. Most trailers have adjustable rubber rollers with nylon bushings or wooden chocks which are cushioned. These help absorb road shocks and prevent transmission of the shocks to the boat's hull. These supports must be aligned properly to prevent warping the hull.

The first time the boat is placed on the trailer, the rollers and supports should be adjusted to conform to the boat's bottom, and the bolts tightened securely. After the initial adjustments are made, they will probably not need further attention except to check the bolts from time to time to be certain that they haven't worked loose.

On smaller boats with lightly-constructed transoms, the outboard engines should be removed while the boats are out of the water. The weight of the engine places a comparatively heavy strain on the transom, and this could cause a deflection or "warp" in the hull. Larger boats, designed for heavier engines, have more substantial transoms. The engines are more-or-less permanently installed and will not accommodate easy removal each time the boat is hauled out of the water. Many boat manufacturers recommend that outboard engines be removed from boats during winter storage.

Proper tie-downs should also be considered in choosing a trailer. Sufficient support for each side of the hull is essential to prevent the boat from shifting while it is on the trailer. Outboard engines increase in weight as they increase in horsepower



2-10 Correctly Loaded Trailer

and size, and the supports beneath the boat's transom must be proportionate.

The trailer must be strong enough to carry the weight that will be placed on it. The load capacity of a boat trailer should not be exceeded. Most trailers will have a data plate that states the maximum load capacity and the correct specifications for the tires. If your trailer does not have such a plate, consult other sources or your dealer for this information. Remember, the "load" placed on a trailer includes the weight of the boat, the engine and all gear that is loaded into the boat.

While trailering, many boatmen haul most of their gear in their boats. If this is done, the load should be distributed so that the heaviest items are placed on the bottom of the boat, directly over a supporting roller or chock. The gear should be secured carefully to keep it from shifting around.

Trailer hitches began as home-made contrivances. They are now carefully engineered. Most are constructed of heavy gauge steel, rust proofed and equipped with safety chains. The trailer tongue is equipped with a locking mechanism which clamps

2-11 Correct Trailer Hookup To Rear of Car or Truck

down on the neck of the ball of the hitch. This prevents the trailer from coming loose. Some hitches have a provision for inserting a cotter pin or a lock to prevent accidental disconnection.

The hitch and ball should conform to current Society of Automotive Engineers' Standards for passenger car trailer couplings. Under these recommendations, trailers are classified by gross weight. Rather than go into the details of these recommendations, suffice it to say that unless your trailer's gross weight (including the boat) exceeds 5,000 pounds, a 2" diameter ball will satisfy the requirements. A distance of 28 inches between the towing vehicle and the trailer is usually provided by most hitch installations.

Boat trailers must be licensed just as automobiles. Most states have regulations pertaining to trailer ownership and operation. Periodic vehicle inspections made by law enforcement agencies also include boat trailers. Particular emphasis is placed on lights and reflectors, towing hitches, brakes, safety chains, size limitations and weight. Many states have adopted brake regulations recommended in the Uniform Vehicle Code that all trailers weighing more than 40% of the towing vehicle must be equipped with an integral brake system as well as the other required safety equipment.

In most states a boat trailer is considered a separate vehicle. It's a good idea to ask your insurance agent if your boat insurance covers your trailer. If not, a provision to this effect should be written into your car or boat policy.

Trailering Safety Precautions

Before leaving home:

1. Be certain that the boat is secured properly on the trailer.
2. Inspect all lines, tie-downs, and the winch. Tighten as necessary and replace any that show signs of fraying or strand separation.
3. Determine that all trailer lights are operating satisfactorily.
4. Test the trailer brakes.
5. Inspect the hitch and safety chain.
6. Check the pressure in the tires.

On the road:

1. Drive carefully, allowing for the extra length of the car and trailer when negotiating turns.
2. Allow more time for stopping.
3. Watch speed limits. Many states have lower maximum speed limits for cars towing trailers.
4. Pull *well off* the road periodically and walk completely around the rig. Look things over carefully. Glance at the tires and examine

the wheel bearings for overheating. Test the tie-downs and check any gear which is being carried in the boat.

These simple precautions, if observed, will make trailering your boat a pleasant and relaxing experience. Trailering the boat to the water can be part of the pleasure of boating. There is no reason why it should not be.

Conclusion

This chapter has served as an introduction to boating terminology — the colorful language of the mariner. The use of correct nautical terminology is important when conversing with other boatmen and those aboard your boat. It could save many dollars in your dealings with boat repair yards.

There are many types of boats, large and small. They may be powered by any one of several methods of propulsion. They have different hull characteristics and may be constructed of a wide variety of materials. Some boats are left in the water for long periods of time while others are hauled out and trailered home immediately after use. Some pleasure boatmen cruise on rivers. Others sail on large lakes, while still others navigate the open waters of the high seas.

With such a variety of boats and boating preferences, one might ask if there is anything that all boatmen have in common. Where is the thread that binds them together? It's elusive, but it's there! Neophyte pleasure boatmen who do not develop a love for boating soon sell their boats and disappear from the scene. Those who survive this initial screening are all cut from the same cloth, regardless of how and where they do their boating. For instance, would you refuse to assist a fellow boatman whom you encountered in trouble afloat, even if he were a complete stranger? In fact, have you ever *really* met a complete stranger on the water?

We think not. Further, we're willing to bet that you never will!

CHAPTER 3

Boat Handling

Introduction

Handling a boat is an interesting and sometimes exciting experience. Often, a first-time boat owner may find it is so exciting as to be frightening. His boat may respond in ways that he does not expect. He may well feel that he does not have control over the situation.

Handling a boat, like driving an automobile or flying a plane, is a skill which is acquired as the result of study and practice. Basic boat handling skills require, as a first step, a knowledge of how and why boats behave as they do. This can be obtained by trial and error—but errors on the water can be dangerous to the boatman and to others nearby. A certain amount of basic knowledge can be learned in the classroom at much less risk and in a more efficient manner.

Once the basic principles are learned, they should be applied on the water. The boatman should learn about *his* boat. This understanding must include everything about the vessel; its hull, with its characteristics and limitations, its machinery and rigging, its underwater gear and all equipment aboard. Once this understanding is achieved, it is reinforced by constant practice. How does the vessel behave in turns? How much way is required for effective rudder control? How does she behave in varying sea conditions? If left to her own resources, will she wallow in the trough or turn her stern into the wind? How responsive is she in close quarters? How well does she carry her way? What are her backing characteristics? In a seaway, is the hull tender or stiff? How much power is available for emergencies? What is her fuel consumption? How much fuel does she carry? What are the effects of a beam wind, and what allowances must be made in these circumstances? These questions, and many more, must be answered by the boatman; and their answers must be thoroughly understood. He must practice to improve his skills and develop a solid feeling of confidence in himself and his equipment. This cannot be done ashore but a good knowledge of what is actually happening when he turns the wheel or opens the throttle can make the learning process quicker and easier.

The propeller and the rudder are the two principal devices which control the boat. They both act in complex ways—but by looking at a simplified picture of their actions we can understand more about their practical effects on the handling characteristics of the boat.

The Propeller

Almost all pleasure boats are propeller driven. Propellers are designed to rotate in either a clockwise or counter-clockwise direction. When the propeller is viewed from aft (looking forward) and it is seen to turn in a clockwise direction to propel the vessel forward, it is called a right-handed propeller.

3-1 Left Hand Propeller Right Hand Propeller

If it is seen to turn in a counter-clockwise direction it is called a left-handed propeller.

Propellers may be easily identified as right-handed or left-handed by inspection. Also, most propellers are stamped "RH" or "LH" on the hub. Other markings which may appear on the hub are the diameter and pitch. The diameter is generally measured in inches and represents the diameter of the circle described by the outer tips of the rotating blades. Pitch is also measured in inches, and represents the *theoretical* distance that the hub would travel forward with one complete rotation of the propeller. Pitch is easiest to visualize if one thinks of the propeller as moving through a solid mass. The pitch would be the distance in inches that the screw would penetrate the mass in one complete revolution. One point to keep in mind concerning the pitch dimension is that this is a theoretical value only, since the propeller is working in a liquid and not a solid.

Surprisingly, not too many people know how a propeller works. Because a propeller is made up of twisted surfaces resembling a screw (technically a helicoid) it is often called a screw. But it doesn't simply work its way through the water like a screw in wood. If this were so the best blade shape would be sharp at the leading edge to "bite" the water easier. If you look closely at a propeller blade you will see that, in section, it is shaped about like an airplane wing.

It is in reality a lifting surface, just like an airplane's wing. As it rotates, water passes over the blade's section. There are a lot of high-powered mathematical formulas about the effects of this—but basically the water going over the "fat" side which faces forward relative to the boat has farther to travel than that which goes by the "thin" side which faces aft. This results in a reduction in pressure on the fat side and the propeller tends to move in that direction.

A marine propeller is *not a pump!* It is not a reaction machine pulling in water from ahead and pushing it astern. Because it does not operate in ideal conditions some of this does happen, and it can be of use to the boatman—maneuvering at low speeds. But, to understand a propeller's operation one must consider it as being like a spiral shaped air foil.

Boat propellers, unlike airplane propellers or wings, operate in water. This means that because of the high density of water we can use a smaller propeller for a boat than for an airplane of the same horsepower. But we are faced with a serious practical limitation called cavitation. On the extreme, cavitation can reduce propeller efficiency and can seriously damage the propeller and even the struts and rudders aft of it. How and why does this happen? If we ask the propeller to absorb too much power—to develop more lift than that for which it is designed, we get cavitation. As we increase RPM's—move the "air foil section" through the water faster—the pressure over the "fat" side gets less and less until a point is reached where the water passing over the blade literally boils—yes, it turns into *steam!* This sounds pretty far out, but a dish of water in a vacuum chamber in a laboratory can be made to boil not by increasing the temperature but by reducing the pressure acting on it. A highly loaded propeller does the same thing, not in a lab, but on your boat! The "cavity" limits the amount of thrust we can get from our propeller, but a *cavitating wheel still produces a lot of thrust.* The trouble comes because there is a peak of low pressure about ⅓ of the way aft of the blade's leading edge. After that, the pressure is greater and the steam bubbles condense violently. This "implosion" hammers on the blade and can erode it away over a period of time. Some of the "implosions" may even take place on the struts and rudder aft of the propeller and erode these as well.

In a supercavitating propeller, the pitch, diameter and blade shape are designed so that high horsepower can be used efficiently under high cavitation. But the trailing edge of the blades are "chopped" away so that the "implosions" have nothing on which to hammer. The detail design of a supercavitating propeller and a regular non-cavitating propeller is very different. Loading an ordinary propeller to the cavitating point makes it operate in conditions for which it is not suited and reduces its efficiency sometimes quite suddenly and may lead to engine overspeed and other problems.

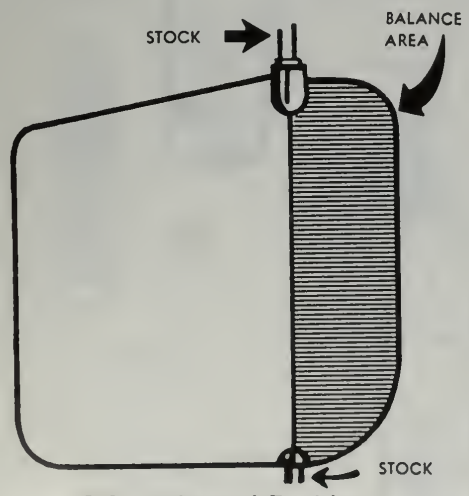
Almost all single-screw boats have right-handed propellers. There is no advantage in efficiency from a right-handed propeller but most boatmen are used

to it and its low speed maneuvering characteristics. A left-handed propeller can cause practical operator problems for one who is used to a right-handed propeller and often requires re-training of the boatman. Twin-screw boats usually have "outboard turning" propellers. This is important in low speed handling characteristics because of the complex interaction of propeller and hull. The explanation of the reasons would be lengthy and technically "deep" but it is a proven fact that *inboard* turning propellers make a boat extremely difficult to handle at low speeds. Twin-screw boats are far more maneuverable at slow speeds than single screw craft. Beside being able to apply varying amounts of power to each propeller separately, the propellers of twin screw boats are placed on either side of the centerline, giving them greater turning leverage.

The Rudder

An inboard powered vessel is steered by means of a vertical blade called the rudder which can be pivoted to either side of the centerline. The size and shape of the rudder have a considerable effect on its operating characteristics. Boats which are designed for relatively slow speeds usually have large rudders, while higher speed boats have smaller ones. The rudder is generally placed directly behind the propeller, or nearly so. Modern twin screw pleasure craft almost always have twin rudders, each of which is placed behind its respective propeller.

The pivotal shaft to which the rudder is attached is called the stock. On most rudders, the stock is attached to the forward edge of the blade. Certain rudders are designed with a portion of the blade projecting ahead of the stock. These are called balanced rudders. When a balanced rudder is pivoted off the center line, the portion of the blade which is ahead of the stock is placed on the opposite side of the centerline. Although this may be only 15 to 20% of the surface area of the blade, it has the effect of taking a considerable amount of strain off the steering gear and thus makes the boat easier to handle.



3-2 Balanced Rudder

3-3 Rudder

The rudder is another lifting surface. It can be either a symetrical airfoil or a flat plate. As we turn the rudder from its amidships position while the vessel is making headway, it creates a lift, just like an airplane wing, and the resultant force tends to move the stern of the boat sideways.

Even good symetrical airfoil rudders lose their efficiency when turned too far off the centerline, and much of the turning force is lost. It is for this reason that most rudders are limited mechanically to a "hard over" angle of about 35° from amidships.

Practical Effects of Propellers and Rudders

The first thing to remember when operating a powerboat, or any boat for that matter, is the fact that when the rudder is moved off centerline, it is the *stern* and not the bow that changes direction first. This becomes especially important when getting underway (under headway) from a float or pier. Under this circumstance, putting the rudder away

from the side nearer the float will only drive the stern of the boat into the float.

3-4 Leaving the Dock

Maneuvering at Speed

Maneuvering at speed is usually a "rudder only" operation. When we put the rudder over, the lift force tends to force the stern sideways. The boat pivots at a point which is usually forward of amidships and the bow is initially slightly inside the turn track line with the stern outboard.

Boats at speed usually settle into a turn nicely because of the forces of the water on the moving hull. As long as the lifting force of the rudder is applied the boat will continue to turn. Returning the helm to amidships will slow the turn and the boat will tend to straighten out. But in a very heavy boat, a bit of opposite rudder (meeting her) may be helpful in settling on the new course.

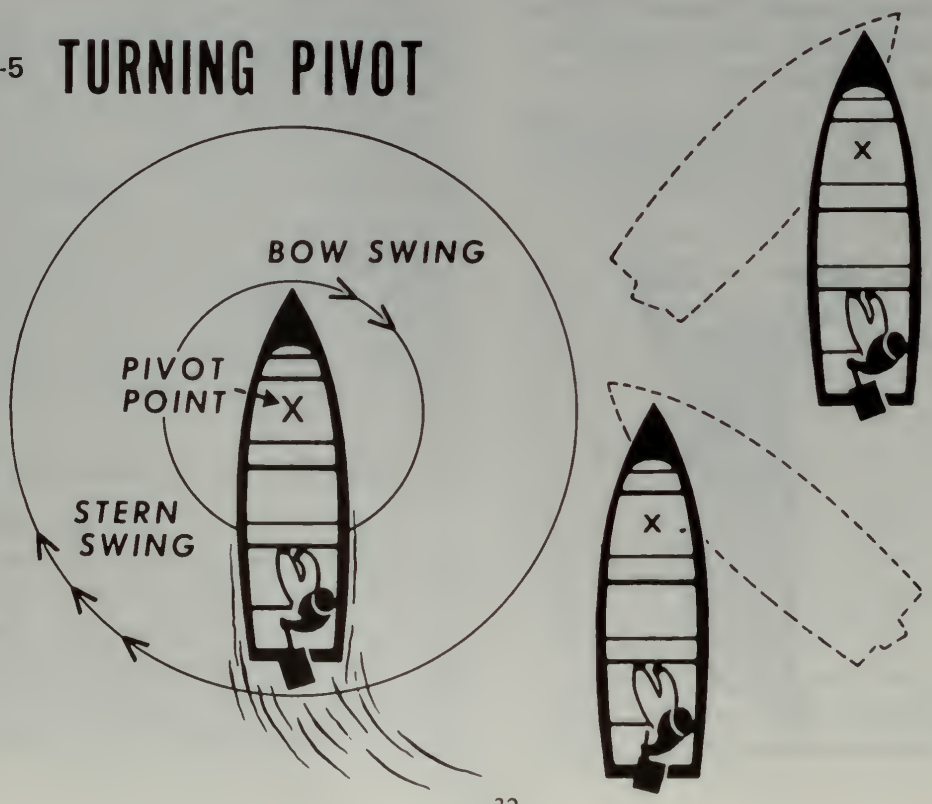
Low Speed Maneuvering

Single Screw

If our boat is dead in the water, there is no flow over the rudder. The rudder can be moved from hard over to hard over without effect. As we put the engine ahead, the propeller's lift tries to move the boat ahead—but the boat has inertia—it resists a change in motion, and the propeller acts practically in a different manner than it does at speed.

Without going too deeply into the analysis of propeller action, we should be aware of the fact that a rotating propeller develops a component of torque in addition to the component of thrust. The thrust component propels the boat while the torque component generates a transverse force through the shafting which may tend to force the stern to port or starboard. When a boat is dead in the water, and the engine is placed ahead, both thrust and torque

3-5 TURNING PIVOT

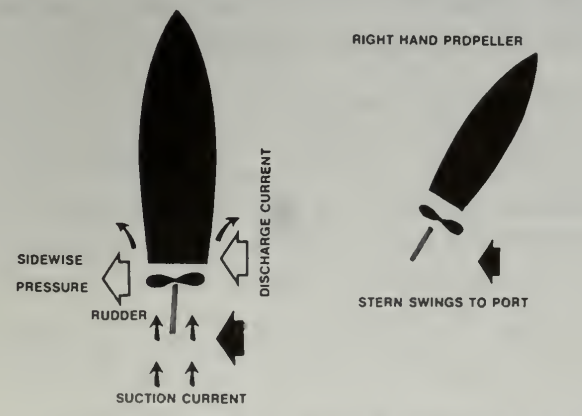


are initially large. Most of the initial thrust is overcome by the vessel's fore-and-aft inertia, but the torque is relatively free to react and the stern may be forced to the side.

The initial practical effect of the right-hand turning propeller of a single-screw boat is to force the stern to starboard. There are exceptions but this is the general rule. The propeller wash also forces water over the rudder. More than one boatman who didn't realize that his rudder was hard over when he hit the throttle has had a big surprise. The sideways propeller forces grow less important as speed builds up and a boat with any significant forward motion handles quite normally.

Backing the engine of a "right-handed" boat tends to swing the stern to port. This is caused by an interaction of the propeller and the hull which decreases the effectiveness of the portion of the propeller which is "on top," nearest the hull. It is a complex phenomena which depends to some extent on hull design as well as propeller tip clearance from the hull and other factors. There are boats which will back dead straight, some which back to starboard (although this is most unusual for a "right-handed" boat) and a few which will do the unexpected. There are many factors involved, so each boatman should learn his own boat's behavior patterns. It is the wise boatman who realizes that most "right-handed" boats back to port, but *who doesn't always count on it!*

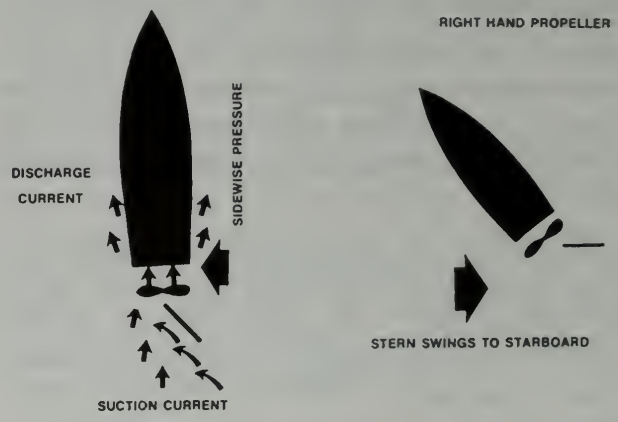
When backing down it is good practice to have the rudder amidship initially. This is especially true if there is a direct "tiller line" steering system as is sometimes found on older boats. The resultant "kick" on the wheel from a hard backdown of one of these boats with the rudder part way over can damage the steering system and has been known to break a boatman's wrist. In any case the strain on the steering system can be considerable.



3-6 Single Screw Vessel with Headway, Propeller Backing

Rudder Action While Going Astern

As sternway builds up the rudder begins to have a marked effect on maneuvering and the boat backs just like a car. There are many rules on the "reverse" effect of the rudder but this is the simplest: When backing down, right rudder will swing the *stern* to the right. The bow, of course, will go to the left. If the stern motion is stopped and the boat is put ahead, the rudder must be shifted to keep the bow swinging in the same direction.



3-7 Single Screw Vessel with Sternway, Propeller Backing

Twin Screw Boats

Since a twin-screw boat has two "thrust producers" (propellers), one on each side of the centerline, it is usually a joy to maneuver at low speeds. By going ahead on one screw and backing down on the other, the boat can be turned very easily and practically within her own length.

Outboards and In/Out Drives

These boats are steered by turning the line of thrust of the propellers. They have no rudders, although the lower units and shaft housings have some slight rudder effect. They pose no special problems in handling except that power is required to turn the boat. One cannot coast alongside and control the

heading of the boat by rudder action alone as is easily done with a conventional propeller and rudder system. They are responsive and handy. For example, the stern can be moved toward or away from a pier or float by positioning the thrust angle properly and applying just a touch of power. Thus, maneuvering is much simpler with an outboard or I-O drive than with an inboard driven boat. Even backing down is easier though most outboard driven craft steer poorly while reversing because the bow tends to swing away from the line of travel. When making a partial or complete turn with an outboard, reduce speed and turn in an arc of sufficient width so the boat will stay on an even keel. Never attempt short turns at high speed. Countless capsizings have resulted from this foolhardy practice.

The Technique of Docking and Maneuvering

One of the best ways to judge the competence of a boatman is to observe the manner in which he gets his craft underway from a float or pier, and how he places his boat alongside the float when returning to his dock.

One boat is seen to get underway as the result of much running back and forth and much pushing and pulling, all to the accompaniment of much shouting of orders, generally by everyone aboard to nobody in particular. Another boat is seen to get underway with all persons comfortably seated, the lines quietly let go, and the craft skillfully maneuvered clear of the float or pier. Both of these vessels have gotten underway successfully. Both have accomplished the same result—but what a difference in technique!

At this point, the reader might argue that the first boatman could be comparatively new to the sport, while the second boatman obviously was an "old pro." It is conceded that this might well be the case but one does not advance from the first situation to the second without a thorough understanding of the forces at work, which may be encountered under varying conditions.

Before Getting Underway

Before getting underway, the prudent boatman will be found to be quite busy. Sailboat skippers generally check their rigging—stays, shrouds, halyards and sheets. Sails are made up and ready to hoist. Both sail and powerboat skippers should check all of the vessel's systems and gear, usually with the aid of a check list. The fuel in the tanks should be measured (or the gauges read) and the engine oil level should be determined. All lights, including running lights, should be seen to be operating properly. The whistle or horn should be sounded briefly. (One possible exception to this would be if the departure were from a crowded anchorage and scheduled for 0500 hours!) The condition of the bilges should be checked. Hand lines should be broken out, ready for use. Anchors should be bent on and ready to let go. Lifesaving devices should be taken out of their lockers and placed in readily accessible places. All electronic gear which will be used should be turned on. Hatch covers shoud be open to allow engine and fuel tank spaces to ventilate and bilge blowers, if any, should be operating. A heaving line and boat hook should be available for instant use. In short, all equipment aboard should be determined to be in satisfactory operating condition. Only when this is done, is the vessel in condition to start the engine or engines.

Starting Engines

When ready to start engines, special precautions are taken. Even though the engine and fuel tank compartments have been thoroughly ventilated, it is still necessary to test for gas vapors which may be present in these spaces. This can be done by activating an electronic vapor detector, or by activating our built-in vapor detector—the nose! The nose is generally far more sensitive than a device in detecting gasoline vapors, and it is the nose that should be satisfied that no vapors are present.

The proof of the pudding will be when the starter is engaged. It is at this point that ignition is introduced to the situation. If the proper mixture of gasoline and air exists, it is at this point that the day's activities could end abruptly in a flash of flame as the mixture explodes with great force.

Once the engines are started, the temperature should be allowed to come up somewhat, to prevent stalling. However, excessive idling should be avoided. It is usually best to allow the engines to warm up under a load.

Getting Underway

With the engines started, and all gauges reflecting desired readings, it is time to get underway. Before casting off the mooring lines, a careful inspection should be made of the immediate surroundings. All hazards and obstructions should be noted, and the direction and strength of the wind and current should be known.

This chapter will develop situations which will be encountered while docking and getting underway. Before getting into this, however, the boatman should be reminded that a slow speed should be maintained through crowded anchorage or marina areas. The boatman is legally responsible for any damage caused to others by his vessel's wash. Most marinas have a 5-knot speed limit but this may be too fast if the wash doesn't flatten appreciably within a few feet from the stern. All fenders (which may be dangling) should be taken in. Mooring and hand lines, and all loose gear about the decks, should be secured.

Leaving the Dock

Leaving a dock and returning to it require a certain level of skill on the part of the boat operator. In all of the maneuvers involved in docking and leaving a dock, it is imperative that certain facts be kept clearly in mind. The first and most important point to remember is that the stern is the only part of the boat that can be steered. As stated earlier in this chapter, the stern moves sideways and must always be watched. This is not to say that the bow must not also be watched but all too many boatmen concentrate on the bow and in this concentration, slam the stern into the wharfs and floats with damaging results.

Wind and Current

There are also other factors at work however, if the boatman is alert, he can make these forces work for him. These forces, which are almost always present, are wind and current. Most boatmen (other than our sailboat friends) think of wind and current as hindrances. Both wind and current can be considerable help in maneuvering if the boatman knows how to employ them.

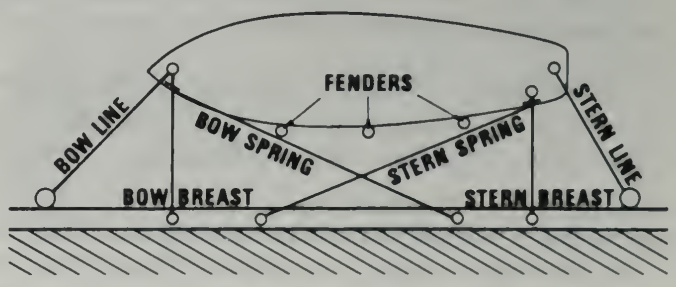
One of the first surprises experienced by the newcomer to powerboat operation is the relatively great effect the wind has on his vessel. Deep draft boats, with comparatively low freeboard, are far less affected by the wind than by the current. This is because there is more underwater body for the current to work against on deep draft boats, while there is less topsides area (and cabin structure) against which the wind can work. Most powerboats are not deep draft vessels, and present high topsides and relatively large cabin areas to the wind. Many powerboats may be affected more by the wind than by the current. This is important to remember while underway; but it is most important to remember when maneuvering in close quarters.

Generally, the bow of a powerboat has higher freeboard than the stern and is considerably less heavy. Consequently, the bow will almost always be blown downwind at a faster rate than the stern. This accounts for the characteristic of most powerboats to turn their stern into the wind if left to themselves. In some marina areas, where maneuvering is necessarily restricted to close quarters, it is not physically possible to get up enough way to bring the bow up into the wind. Under these conditions, the boatman has no choice but to go into reverse and cooperate with the wind instead of attempting to resist its effects.

The Use of Lines

We generally think of lines as simply a means of keeping a boat tied to a pier. These lines are known

DOCKING LINES



3-8 Mooring Lines

as mooring lines, and it might be well to think about lines briefly before continuing on.

The most often used mooring lines are the bow line and the stern line. These are simple to employ and are usually sufficient, provided that fenders are suspended from the hull at strategic points to keep the hull from chafing against the float.

If the vessel is to be left alongside a pier or float for a long time, as with a permanent mooring, the use of breast lines and spring lines should be considered. Breast lines prevent sideways movement and spring lines limit the fore-and-aft movement of the vessel. If moored to a pier or wharf in tidal areas, it is important to leave sufficient slack in all lines to accomodate the rise and fall of the tide.

Spring lines may also be used in close quarters to help the vessel into or out of a slip or to facilitate maneuvers alongside a wharf. If the spring line is to be handled by those aboard the boat, both ends of the line should be aboard, with the bight around a bollard or cleat on the wharf. A spring line is let go by hauling in on one end of the line. If used under these conditions, a spring line must be tended carefully to be certain that it does not become fouled on the rudder or propeller. Under no conditions should a spring line, which is being used to assist a maneuver, be tied off to a cleat or bitt aboard the boat. A half turn around the bitt or cleat is usually all that is required. The spring line should be able to be adjusted as necessary and cast off quickly when no longer needed.

Leaving a Slip

In this case, and in all cases to follow, it is assumed that the vessel is a right-hand single-screw craft of inboard propulsion.

Some boats depart from their slips by backing out and little trouble should be encountered with this maneuver. Once the engine has been started and all is ready, all lines are cast off. The rudder is placed amidships, with the engine in slow astern. The boat will back down slightly to port. At this point, the starboard bow should be tended carefully, as it might swing into the right hand finger pier or float. When the bow is clear, apply hard left rudder. The turn will become more pronounced. When sufficiently clear, apply hard right rudder and go ahead with a short burst of power. This should check the sternway and stop the boat. The rudder is now placed amidships (or as necessary to pick up the desired heading) and the boat proceeds under slow speed ahead.

Getting Underway from a Float, Pier or Wharf

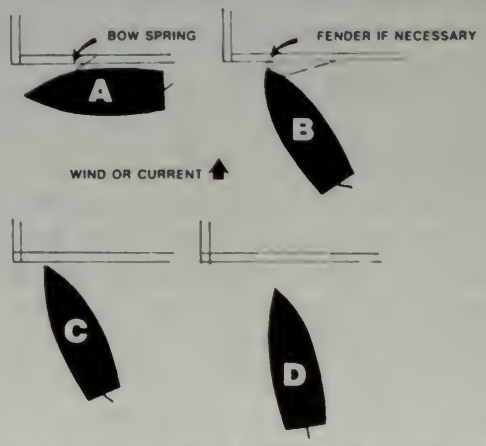
In many cases, a simple maneuver such as getting underway can be complicated by the presence of other craft immediately ahead or astern of your boat, thus severely restricting your choice of alternatives. Wind or current could also become a factor in the sense that the boat is being blown onto or away from the float.

Leaving a Dock, Wind Blowing off the Float

In this case, the wind will be of considerable help in getting clear. Cast off the stern line, then the bow line. The boat will drift clear, with the bow falling off more rapidly than the stern. When sufficiently clear of all obstructions, place the engine in slow ahead and proceed in the desired direction.

Leaving a Dock, Wind Blowing onto the Float

Getting away from a float, when the boat is being set onto it by the wind, will generally require the use of a spring line. Cast off the stern line and hold an after bow spring line. Have fenders over the starboard bow and tend the line carefully. Go ahead slowly with full right rudder. The spring line should check the forward movement and the stern will swing away from the float and into the wind. Adjust the engine speed as necessary to overcome the

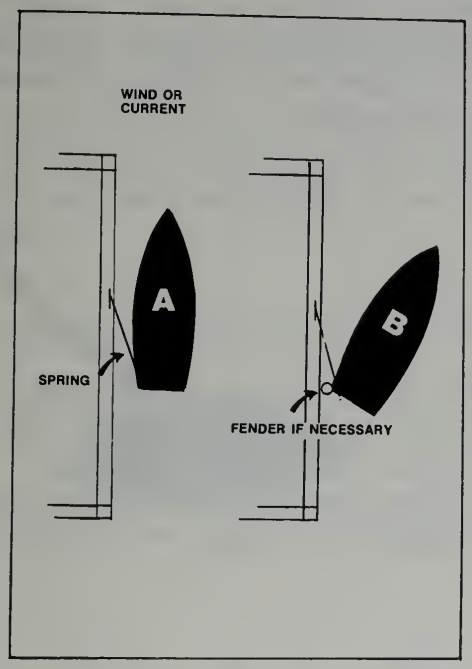


3-9 Leaving a Dock, Wind Blowing onto the Float

force of the wind. When the stern is clear of all obstructions, put the rudder over to hard right, place the engine in slow astern, and cast off the spring line. The boat will back directly into the wind. Adjust the helm as necessary to avoid oversteering and, when sufficiently clear of the float, go ahead with a short burst of power to check the sternway. From this position, come right or left to the desired heading under slow ahead.

Leaving a Dock, Wind on the Bow

In this case, the wind can be of considerable help. Cast off the bow line and hold a forward quarter



3-10 Leaving a Dock-Wind on the Bow

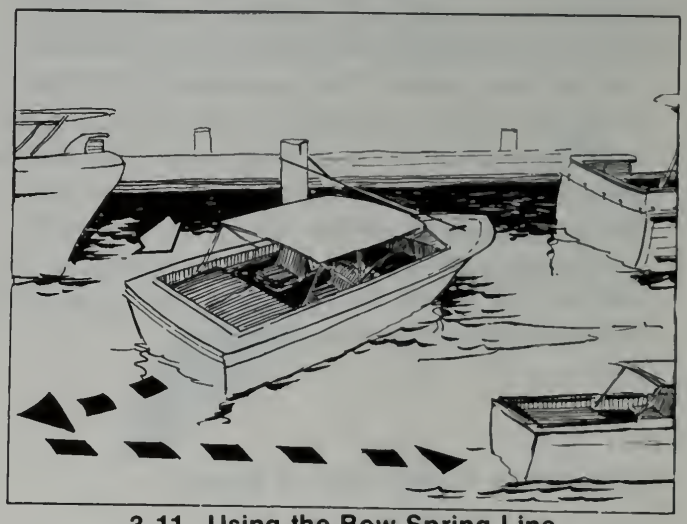
spring line. This will allow the bow to fall off, away from the float. It might be necessary to start this by a gentle push with a boat hook against the float. When the bow has fallen off sufficiently to be clear of all obstructions, cast off the spring line and go ahead slowly with left rudder.

If the desired direction of travel is downwind, execute the above maneuver with the spring line on the outboard quarter cleat. Hold the spring line until the wind has blown the bow sufficiently clear. Cast off the spring and go ahead slowly with right rudder.

Leaving a Dock, Wind on the Stern

Cast off the stern line and hold an after bow spring line. Have fenders over the port bow and tend the line carefully. Go ahead slowly with full left rudder. The stern will swing away from the float. When the stern is sufficiently clear of all obstructions, place the rudder amidships, cast off the spring line and place the engine in slow astern. The boat will back into the wind with the bow tending to fall off to starboard. When clear, go ahead with a short burst of power to check the sternway. Go ahead slowly with right rudder.

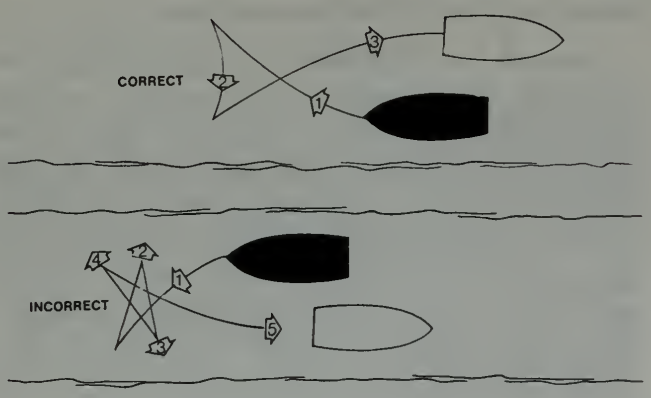
In close quarters, where there is little room to maneuver, it is usually not practical to attempt to bring the bow into the wind. If the desired direction of travel is upwind, it is generally best to travel under sternway to a point where there is more space to maneuver.



3-11 Using the Bow Spring Line

Turning in a Narrow Channel

In some cases it may be necessary to make a complete 180° turn in a channel that is too narrow when compared to the boat's minimum turning circle. If the boat is a right-hand-screw vessel, start the turn as close to the left hand side of the channel as possible, Put the rudder over to hard right and LEAVE IT THERE. Alternately go ahead and reverse until the turn is complete. When the boat is properly aligned with the channel in the opposite direction, put the rudder amidships and proceed under slow speed ahead.



3-12 Turning a Right Hand Screw Boat in a Narrow Channel

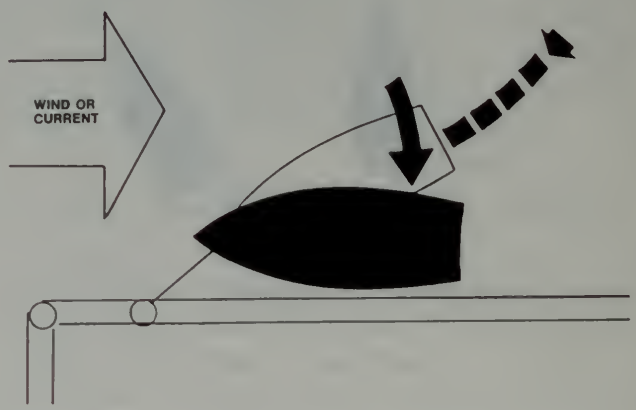
If the desired new direction of travel is into the wind and if the wind is sufficiently strong to cause considerable leeway, a turn in a narrow channel under these conditions may not be possible without the use of an anchor. The procedure in this case is to quickly lower a bow anchor and fall back on this anchor until the bow is into the wind. The anchor rode is picked up as the boat heads into the wind to the position of the anchor. This maneuver requires quick action on the part of the person tending the anchor and is not recommended for the average boatman except in extreme cases.

Mooring to a Pier, Float or Wharf

Docking a boat can be a source of pride or embarassment. Frequently, a would-be salt approaches a pier at breakneck speed, throws everything into reverse and if he doesn't plow through the pier, he gets alongside just in time for his own wake to pound his boat against the pilings.

Don't be a "hot rodder." Make the landing approach cautiously and slowly. All that is needed is enough speed for the boat to respond to the rudder. It may not look as spectacular but it is certainly better seamanship, safer and in many cases, much cheaper. It is also good seamanship to have fenders, mooring lines, a heaving line and at least one long line ready well in advance of actual docking.

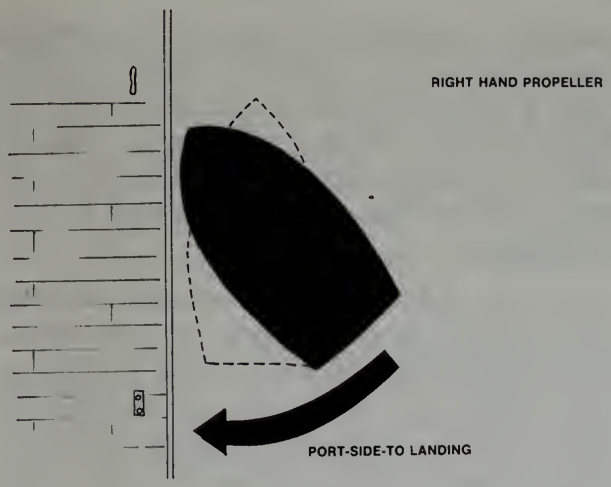
Because of the varied construction of piers and floats, you will not always have a choice of which side of the pier or float to make your landing. With a right-handed screw vessel, is is usually easier to get alongside port-side-to than to get in starboard-side-to. Whenever wind or current is a factor in the situation, the approach should, if possible, be made from downwind or downstream. In this way, the bow will be headed into the wind or current. Downwind landings are difficult and require a higher degree of skill than landings into the wind but there may be certain situations where this cannot be avoided. All landings should be carefully planned in advance but downwind landings require extra care and planning. A mistake under these conditions will usually cause the boat to slam into a wharf or into another boat with costly results.



3-13 Docking Against Wind or Currents

Docking with no Wind or Current

A landing is usually made by bringing one of the bows alongside the wharf or float under slow headway and reversing to stop the boat. If there is no wind or current, a boat with a right-hand screw should land portside to the wharf. When the port bow is put alongside and the boat is backed to check the headway, the sidewise presure of the backing screw sends the stern alongside. In a starboard-side-to landing, the same propeller effect sends the stern away from the float. It is obvious

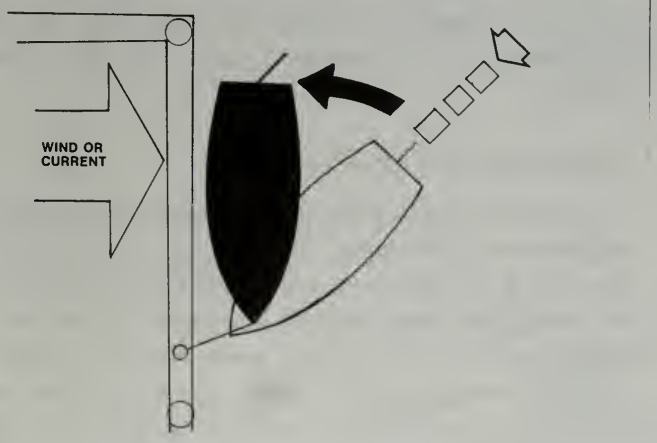


3-14 Effect of Backing Propeller

then, that a starboard-side-to landing must be made at a very flat angle to the float and with as little headway as possible so that little or no backing is necessary.

Docking, Wind Blowing off the Float

The approach must be made at a relatively sharp angle since the wind will tend to blow the bow down. It will be necessary to hold a certain amount of right rudder to maintain the correct heading. A fender should be rigged on the starboard bow.

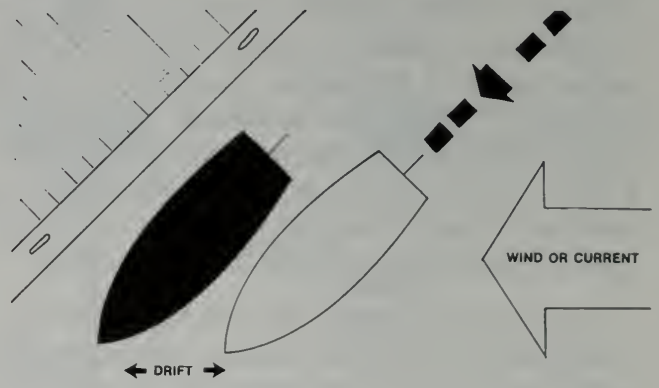


3-15 Docking from Leeward

When close aboard, send the bow line ashore and put the rudder over to hard left. Go ahead on the bow line, which will act as an after bow spring. The stern will come alongside the float. Send the stern line ashore and secure the engine. Adjust mooring lines as ncessary.

Docking, Wind Blowing onto the Float

The approach should be made at a flat angle, keeping in mind the tendency of the wind to blow the boat toward the float. Since the bow will fall off more than the stern, a certain amount of left rudder must be held to maintain the desired heading. Plenty of fenders should be rigged along the starboard side. When in the proper position, reverse the engine to check the headway. The boat will come alongside parallel to the float. This could be a hard landing, depending on the strength of the wind. DO NOT use arms or legs to fend off as the boat approaches the float. Many an arm and leg has been broken or crushed in this manner. The fenders should cushion the shock, with an assist from a judiciously employed boathook or two. When alongside, send mooring lines ashore and adjust as necessary.



3-16 Docking from Windward

Twin-Screw Maneuvering

Up to this point, we have been concerned only with the handling characteristics of right-hand-single-screw boats. The great majority of pleasure power craft fall within this category. However, twin-screw boats are rapidly increasing in popularity and a few words on the handling characteristics of twin-screw boats are in order.

On twin-screw boats with inboard-outdrive units, both propellers are right-handed; but on most twin-screw inboards the starboard propeller is right-hand-

ed and the port propeller is left-handed. The first thing to remember about an inboard twin-screw boat is that it is infinitely more maneuverable than a single-screw boat in close quarters. There are two propellers, turning outboard, positioned on either side of the center line. Twin rudders, which are found on almost all modern twin-screw pleasure boats, are positioned directly behind each propeller. The basic principles which apply to single-screw craft with regard to propeller action also apply to each propeller of a twin-screw boat. The important difference is that, with counter-rotating screws, each propeller can be made to cancel out the undesirable effects of the other. This concept can be used to advantage in maneuvering in close quarters since the effects of the two propeller thrusts can be individually controlled.

In order to understand the principles of twin-screw boat handling, it is necessary to observe the effects of each screw individually. Let's assume that the starboard engine is going ahead, the port engine is in neutral and the rudders are amidships. (Since the rudders operate in unison and are not separately controlled, we will refer to the movement of the rudders in the singular — simply as "rudder amidships.") With the starboard engine going ahead and the port engine in neutral, the boat will follow a course which can best be described as a wide turn to port. The craft will tend to follow an extension of the curve of the starboard gunwale.

If the starboard engine were to be placed in reverse, again with the port engine in neutral and the rudder amidships, the boat would tend to follow an extension of the curve of the starboard gunwale but under sternway.

If the port engine were engaged, with the starboard engine in neutral, the boat would tend to follow an extension of the port gunwale, both in ahead and in reverse.

A twin-screw boat can be made to turn completely in little more than her own length by going ahead on one engine and astern on the other. In the case of the starboard engine going ahead and the port engine backing, the combination of the reactions set up will turn the vessel without recourse to the rudder, and without the necessity of having either headway or sternway.

Since a boat is more efficient when going ahead than when going astern, the effect of the propeller going ahead is greater than that of the one going astern. If both engines are set at the same rpm's, a certain amount of headway will be made while pivoting. This can be cancelled out by increasing the rpm's of the backing engine just enough to offset the headway.

If the craft has single lever controls, the pivoting maneuver is simple enough, with only two controls for the operator to manipulate. If the throttles and the transmissions are separately controlled, the first-time twin-screw operator may find that he has too many controls to operate at the same time. Most twin-screw boat operators set both engines at a fast idle and forget about them. Since the rudder is not used in the maneuver, it too can be forgotten. This leaves only the two gear levers for the operator to manipulate.

Docking the Twin-Screw Boat

The approach to a float, pier or wharf is similar to the previously discussed techniques for a single-screw boat since the ever-present wind is non-selective and will cause the bow of a twin-screw craft to fall off just as it does with a single-screw boat. When the bow is alongside, the outboard engine is reversed to bring the stern in toward the wharf. On a portside- to landing, the starboard engine is reversed; and on a starboard-side-to landing, the port engine is reversed. Because of the two engines, landing can be made on either side with ease by always reversing the outboard engine to bring the stern in.

Undocking the Twin-Screw Boat

Again, the basic principles discussed concerning single-screw craft apply. When getting away with the use of an after bow spring (if tied portside to the float), go ahead on the starboard engine with full left rudder to spring the stern clear. Once clear of all obstructions, both engines can be regulated as to speed. A twin-screw boat backs well because of the counter rotation of the propeller blades which cancel out the effects of individual propeller torque.

Underway with a Twin-Screw Boat

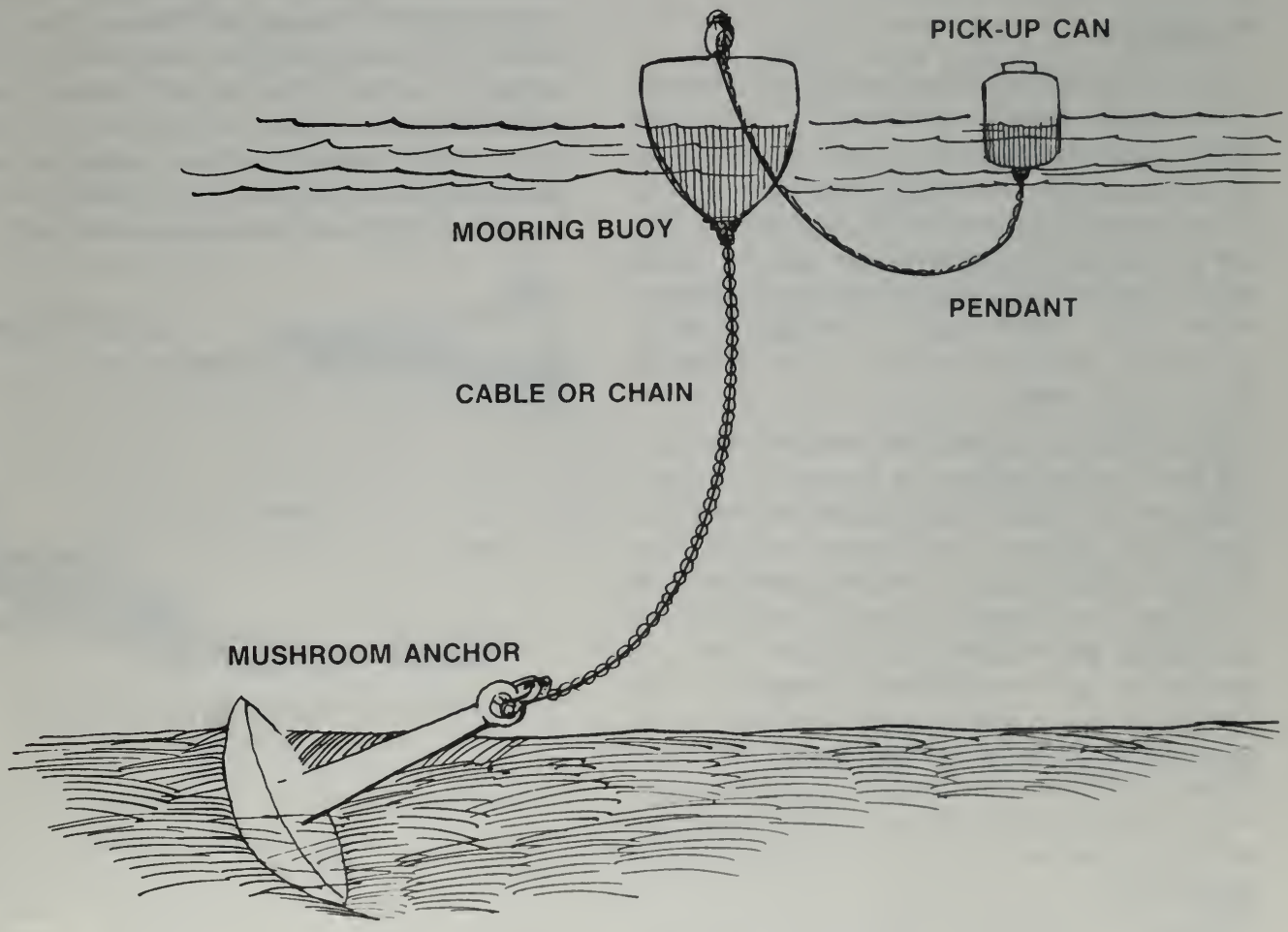
While underway, the advantages of the twin propellers may appear to have been lost. This is not so.

By adjusting (increasing) the rpm's of the leeward engine, the effects of leeway caused by wind or current can be overcome without constantly holding a right or left rudder to maintain the desired heading. Increase the rpm's of the leeward engine a little at a time until the bow ceases to fall off. The boat will now maintain heading with little or no rudder correction necessary.

If the rudder is damaged in any manner while underway, the twin-screw boat can be steered quite efficiently by judicious use of the throttles. Either the port or the starboard engine is set at a desired speed and the other is speeded up or slowed down to accomplish steering. Assuming that we set the port engine at 2800 rpm's (or any convenient speed), the boat can be turned to the left by speeding up the starboard engine, or turned to the right by decreasing the starboard engine's rpm's.

The average boatman who "graduates" from a single-screw to a twin-screw boat historically tends to become "lazy" in his maneuvering. This is due to the fact that less precision is required. With a single screw boat, he had to carefully pre-plan his landings, or other maneuvers, since he could generally depend on getting only one opportunity to make his move. On a landing for instance, if he made a mistake, he could try to back down and recover but in most instances, he was committed on his first approach. A mistake in landing with a single-screw boat usually results in a collision, with subsequent damage to his boat or to some other object.

On the other hand, the twin-screw boat operator can make a mistake on his approach, stop, back down, and make another approach. Since the twin-screw boat will back to port, to dead astern or to starboard, the operator tends to be more relaxed. He



3-17 Typical Mooring Rig

can, with equanimity, become "lazy" and, because of the forgiving qualities and the versatility of his vessel, can usually get away with it.

Mooring to a Buoy

Mooring buoys, like all buoys, are secured to permanent anchors sunk deeply into the bottom. Mooring buoys are usually found near a yacht club, in a harbor, or other places where vessels congregate. It should be noted that mooring buoys are established and maintained specifically for mooring purposes and that they are the only buoys to which pleasure boatmen may legally moor their vessels. Mooring to an aid to navigation is illegal and if the aid is that of a public agency, it is a violation of public law. Mooring buoys offer safe, convenient anchorages, eliminating the need for the boatman to use his own anchor. These buoys also have the effect of keeping many craft anchored in close proximity of each other in an orderly manner.

The Mooring

A mooring usually has four major parts. These are (1) an anchor (usually very heavy); (2) an anchor cable or chain leading from the anchor to a buoy on the surface which is called a mooring buoy; (3) a mooring pendant consisting of a wire cable or fiber line attached to the mooring buoy; and (4) a small pick-up float which is attached to the pendant and makes it quite simple to grasp. A boat is moored by securing the end of the pendant to a bitt or cleat on the bow of the vessel.

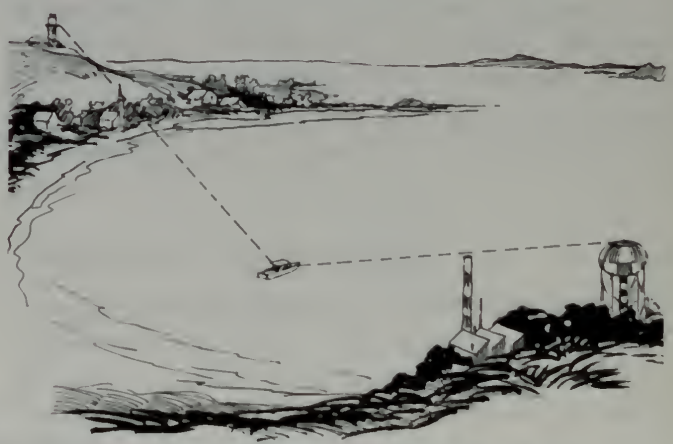
When picking up a mooring, approach the mooring buoy against the force of the wind or current, whichever is stronger. If other boats are moored in the vicinity, observe how they are heading. They will be heading into the wind or current and you can adjust your approach to roughly parallel them, proceeding upwind. Disengage the clutch when you see that you have enough forward motion to reach the buoy. Have a person on the bow pick up the pick-up float, bring the pendant aboard, and secure it to a bow bitt or cleat. Use your engine to maneuver as necessary. After the pendant is made fast, stop the engine and let the boat drift back on the anchor rode.

Leaving the mooring is a fairly simple operation. About the only difficulty you may have is the possibility of getting the pendant fouled in your rudder or propeller. When the pendant is let go, go astern slowly until you have enough room to maneuver without hitting the buoy or fouling the pendant.

Anchoring

The art of anchoring should be mastered by every boatman, if only for his own protection. Many pleasure boatmen become very proficient in navigation and boat handling but neglect the important problem of anchoring once their destination has been reached. The general term applied to all equipment used for anchoring a vessel is *ground tackle.* A large percentage of pleasure boats are poorly equipped in this respect. The selection of ground tackle must be made with due regard to a number of factors.

There are so many variables in the requirements for adequate ground tackle that it is not possible to establish a firm set of rules. Among the factors which must be considered are the type and weight of the vessel and the character of bottom found in the locality. The average depth of water in the anchorage area and the relative strength of the prevailing wind and current should also be considered. Suffice it to say that, unless the ground tackle can be depended upon to hold securely even while the boat is unattended, it is not adequate for the task.



3-18 After Anchoring Check Position with Land Objects

Each boat should carry at least two anchors. One anchor may be of light weight and small size for easy handling. This anchor may be used in good weather when anchoring in protected areas for a relatively short time. The other anchor should be larger and heavier for use during bad weather conditions or

when you intend to anchor overnight when there might be danger of dragging the anchor. The size of the anchors will depend on the size of the boat on which they will be used. Do not trust your own judgement in selecting these anchors. Get expert advice or use the manufacturers' recommendations.

Types of Anchors

There are many types of anchors available on the market. For the average pleasure boat, the so-called "patent" anchor is recommended. These anchors may be known by the names of their manufacturers and have great holding power for their weight. The following types of anchors are available for the pleaure boatman of today.

Yachtsman's Anchor

The yachtman's anchor is an adaption of the age-old kedge, redesigned to overcome some of the kedge's objectionable features. The plane of the stock is perpendicular to that of the arm and the stock is at the head. It has a sharp bill for good penetration of the bottom and the fluke is diamond-shaped to permit the cable to slip past it without fouling as the boat swings with changing current or shifting tide.

Mushroom Anchor

The mushroom is stockless, with a cast iron bowl at the end of the shank. The mushroom anchor is used principally for permanent moorings. This anchor will gradually sink deeply into the bottom and when so embedded, has tremendous holding power.

Fisherman's Anchor

This is a small mushroom type anchor which depends mainly on weight for holding power. It is used principally by small boat and skiff fishermen for deep or protected anchoring.

Grapnel

The grapnel has a straight shank with four or five curved claw-like arms. It is used mostly for recovering lost articles or objects. When used as an anchor, it is used on bottoms of rock or coral, with the deliberate intention of hooking it under a rock or coral head. A trip line, attached to the crown, is a *must* for retrieving it from the bottom.

Northill

The Northill anchor has a stock at the crown instead of at the head. The arm is at right angles to the shank and the broad flukes are set at an angle carefully designed to assure a quick bite and and penetration. The sharp point on the bill causes the anchor to dig into the bottom as soon as a pull is placed on the cable.

CQR Plow

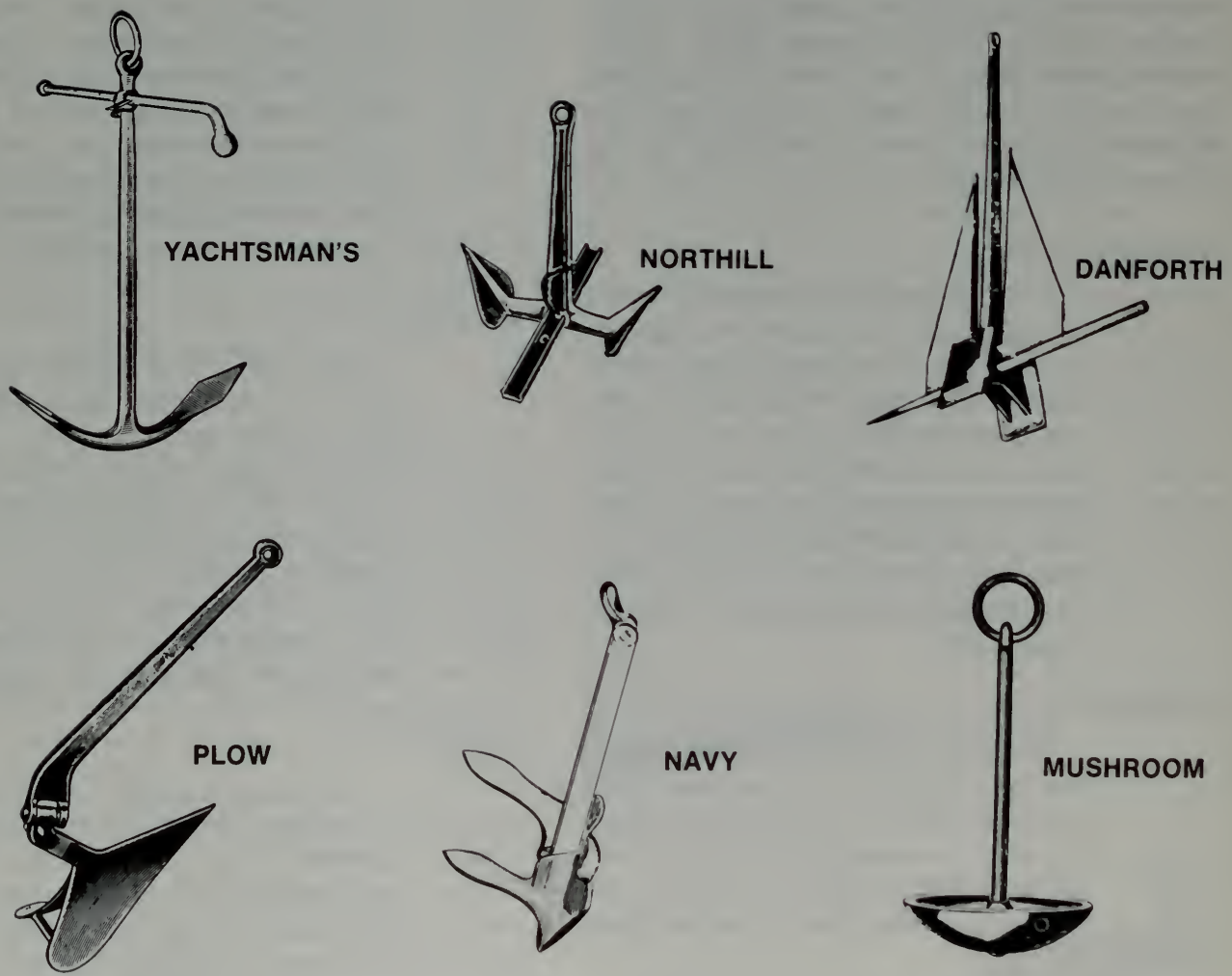
This anchor is of British design and takes its name from the design of its flukes, which resemble a plow. This anchor is designed to lie on its side on the bottom. When a pull is placed on the cable, the flukes dig in quickly and deeply. The CQR Plow is an efficient anchor but is clumsy to handle and stow. It is now manufactured in this country and is gradually gaining favor among boatmen.

Danforth

The Danforth anchor is a by-product of World War II. Many thousands of these anchors (up to 3,000 lbs.) were used to pull landing craft off the beachheads of the Pacific. The Danforth anchor is lightweight and is characterized by long narrow twin flukes pivoted at one end of a relatively long shank. The stock is attached to the rear of the flukes. The flukes engage the bottom quickly and the anchor tends to bury completely under heavy strain.

Navy

The Navy anchor is found principally on large vessels. Because it is stockless, it stows conveniently in hawse pipes. Large



3-19 Various Types of Anchors

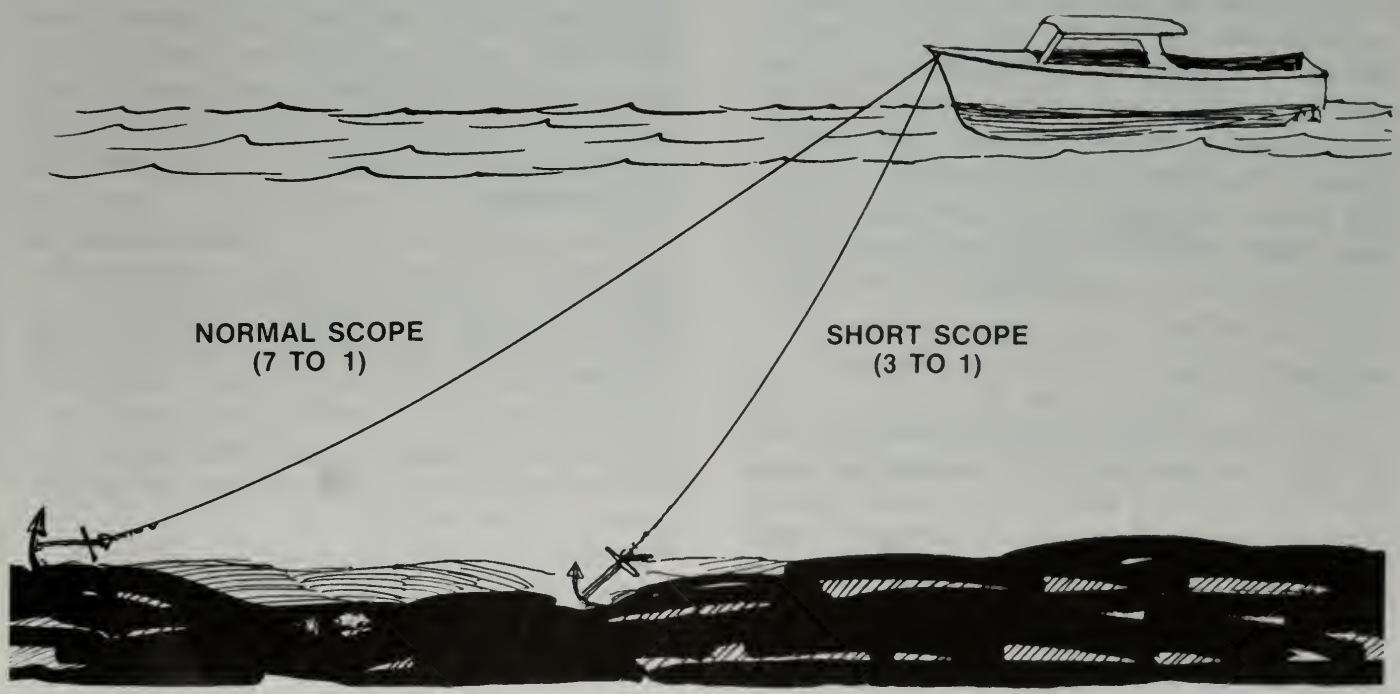
vessels have an ample supply of power to handle heavy anchors. The Navy anchor has a very high ratio of weight to holding power. On small craft, a Navy anchor heavy enough to provide adequate holding power is a backbreaker to handle. If the weight is kept down to make it easier to handle, its holding power is highly questionable. Several adaptations of the Navy type are on the market today, designed specifically for small craft. Some of these are quite adequate.

Rode and Scope

The size and length of the anchor rode will depend on the size of the anchor and the depth of the water. The *rode* is the anchor line and chain on which a boat is riding. *Scope* is the length of the anchor rode. Anchors hold best when the pull of the rode on the shank of the anchor is as near to horizontal as possible. For this reason, the holding power of an anchor increases as the scope is increased. A ratio of 7 to 1, that is a scope equal to seven times the depth of the water, is considered best for most anchoring purposes. A ratio of 5 to 1 is adequate but 3 to 1 is poor unless the weather is excellent, the consistency of the bottom is also excellent and the rise and fall of the tide is not excessive.

How to Anchor Your Boat

There are just a few simple rules to remember when anchoring. Head your boat into the wind or current. Reduce speed and make sure your anchor cable is ready for free running. Reverse the engine and when the boat starts to make a slight sternway through the water *lower* the anchor.



3-20 Proper Anchoring

Make sure that you are not standing on any part of the line as it goes over the side and always be sure that the end of the anchor cable is secured to the boat. This end of the cable is known as the bitter end. Perhaps one reason for this term is that you would feel quite bitter as you watched the end of the line slither over the side. Actually, it is so named because it is the end of the line that is tied to the bitt. The loss of anchor and line in this manner has embarrassed more than one boatman.

When sufficient cable is out, usually five to seven times the depth of the water, stop the engine and make the cable fast to a forward cleat or bitt to make the anchor dig into the bottom. A definite halt in the drifting of the boat should be felt as the anchor digs in. It is wise at this time to take a sight on some stationary object on shore to make certain that your anchor is not dragging on the bottom. If the anchor is not holding, it can usuallly be made to bite in by letting out more line. Bear in mind that an anchor will usually hold better in mud than in sand, so it is good practice to check the character of the bottom. This can be done by either looking on your chart or lowering an armed lead. An armed lead is a lead which has a hollowed bottom and is armed with tallow, wax, chewing gum or bedding compound. This will bring up a sample of the bottom. Be sure to take adequate precautions not to let out so much cable that a changing wind will swing your boat into another boat, buoy, wharf, or onto the shore. If the wind or sea conditions deteriorate while at anchor, take frequent bearings to make sure that the anchor is not dragging. If it is dragging, let out more cable. If this is not practical for the reasons mentioned above, it might be prudent to weigh anchor and set it again in a better location.

Weighing Anchor

When you are ready to leave the anchorage, start the engine and be certain that it is operating properly. Then go ahead slowly to a position directly above the anchor. Have a person on the bow take up the slack in the cable as you proceed. Whipping the line up and down as it comes up will help free it of weeds and grass before it comes on deck. Ordinarily, the anchor will break free of the bottom when the cable stands vertically. It can then be raised to the deck and stowed.

If the anchor does not break free as the result of a good vertical heave, secure the line to a bitt and go ahead slowly for a few yards. If the anchor still does not break free, it is probably fouled. One way to attempt to clear it is to make the line fast to a bitt, and then run the boat slowly in wide circles on a taut line. In those cases where the anchor will not break out under any circumstances, the boat should be run up as close as possible, the anchor cable cut and a marker float attached to mark the remaining end. This will make it possible to attempt to retrieve the anchor later.

Heavy Weather Boat Handling

Although recreational boating is intended primarily to provide recreation, it also entails responsibilities. To some, responsibility is a part of the pleasure of boating. To others, it is accepted as a necessary part of the sport. However, a few boatmen fail to assume the necessary responsibility, and these persons become contributors to the accidents, and resultant tragedies, which occur on our waters. The small boat owner/operator cannot escape the responsibility he assumes when he takes persons aboard with him. He is morally and legally responsible for the lives and well-being of all aboard his craft and also the lives of others in the sense that their rights must be respected and observed. This responsibility could be divided into two major requirements. The first is that the vessel must be seaworthy in all aspects. The second is that it must be operated in such a manner as to insure the safety of all concerned.

A good portion of the first requirement can be purchased. The boatman should be careful to buy a sound boat and good equipment. With regard to the second requirement, emphasis should be placed on knowledge and experience. When a vessel leaves a dock or mooring, she is in the sole charge of her skipper. His subsequent actions will depend to a large measure on how well he has prepared himself to accept his responsibilities.

In United States Coast Guard Auxiliary public education courses, great emphasis is placed on safety. This might very well give the student the impression that pleasure boats operate under the threat of constant danger. In this respect, it should be pointed out that little skill is required to operate

a well-found boat on a calm day in uncongested waters. Adverse conditions, caused by weather or some failure of equipment or personnel, require skillful judgement based on knowledge and understanding of the potential hazards of the sea and the means of combatting them.

Waves

Waves are undulations on the surface of the water This phenomenon is most widely observed but least understood by the average boatman. Consequently, a few words about waves, their causes and effects, should be in order.

Waves are caused principally by the wind. Other causes are submarine earthquakes, volcanic eruptions and the tides. Ripples form if a breeze of less than two knots blows across the surface of the water. If this breeze were to stop suddenly, the ripples would soon disappear. If the wind exceeds two knots, more stable gravity waves are formed. These progress in the direction of the generating wind. Unlike wind or current, gravity waves are not affected by the rotation of the earth. When the wind ceases to blow, energy is no longer transferred to the wave (now called a "swell") and its height begins to diminish. This reduction takes place quite slowly. If a wave is of sufficient strength, it will continue to travel until it reaches shore. In the deep waters of the open seas, "old" waves tend to take on a characteristic shape known as a cycloid. These have gentle slopes, rounded troughs and crests that are somewhat sharper than the slopes. The term employed to describe this type of wave is "swell" or "ground swell."

The distance between consecutive crests is called the wave length and the vertical distance between the crest and the trough is called the wave height.

Small craft are generally quite comfortable in this type of sea as they move smoothly up and down without any violent motions.

As the waves approach the shore and the water begins to shoal, the waves start to feel bottom. When the depth of the water shoals to about one-half of the wave length, the wave begins to decrease in velocity and increase in height. As the depth of the water becomes more shallow, the velocity continues to decrease, while the crests become sharper and the wave length becomes shorter. Eventually, the waves begin to "pile up" on the shore. At this point, the velocity will begin to increase again, and when the wave's height is about one-seventh of its length, the top of the wave will begin to curl and break. Shallow water breakers have a strong horizontal flow in addition to their vertical motion. Also, a strong return flow opposes the base of the advancing waves.

Except in very shallow waters, the horizontal flow of water caused by a wave is negligible. Wave motion at sea is energy moving through the water, not the water itself rushing along. This can best be visualized if you have ever seen the waves caused by wind in a field of wheat. Each stalk sways back and forth but the wheat does not pile up at the downwind end of the field. The motion of a given particle of water in a wave is quite similar to the action of the wheat. If this particle of water were on the surface, it would rise as the wave crest approached, with a slight forward motion. As the crest passed, it would descend, with a slight backward motion. The speed of this slight horizontal motion would increase at the crest and slow down in the trough. When added to the vertical motion of rising and falling, a given particle of water would roughly describe a circle (in a vertical plane) as each wave passes.

Because of the many independent wave systems in the sea at the same time, the surface acquires a complex and irregular pattern. Longer wave systems outrun shorter ones as the systems interfere with one another. This is the principal reason that successive wave crests are not the same height. This may be further accentuated by wave systems crossing each other at an angle. On occasion, this condition will produce peak-like rises.

In very heavy weather, waves with breaking crests may form well out to sea. This is an extremely dangerous condition for the small boat operator and should be avoided if at all possible. The boatman should get weather information before setting out.

Heavy Weather

At the first warning of heavy weather, whether it be by observation of the skies or by radio warnings, the boatman should rig for heavy weather by taking certain precautions before the weather hits. All hatches and portholes should be secured and all loose gear lashed down. Life lines should be rigged

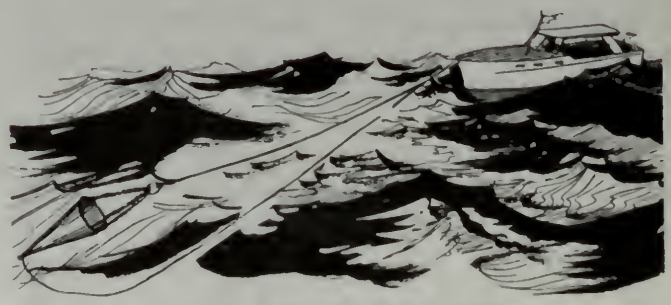
and extra lines should be readily available. If you are in shallow water, be certain that the ground tackle is in condition to let go quickly. If in deeper water, the sea anchor should be broken out and made ready for use if necessary. If you are towing a dinghy, either bring it aboard or set it far back on a heavy tow line. Set the tow line so that the dinghy will ride in step with your boat. The sea characteristics of your vessel and your dinghy are simply not the same. In many cases during a blow, a dinghy has become troublesome and difficult to control. In extreme cases, cut the dinghy painter and abandon it. Be sure the first aid kit is available and if is to be a strong blow, put on your personal flotation devices. Secure the galley and put out all fires. It might be a good idea to prepare sandwiches or other food rations against the time when they will be most welcome. Finally, just before the weather hits, get the best navigational fix that you can. In the decreased visibility, you might not be able to see landmarks as well as you could in clear weather.

Heavy weather, in itself, does not place the small craft in danger. It will, however, test the mettle of both the vessel and her crew. It is comforting to note that a well-found boat, manned by a knowledgeable skipper and an able crew, is usually equal to the task.

Running Into a Sea

As the seas build up, the bow of your boat will be driven into the waves with increasing force instead of being lifted, as is the case in calmer water. This causes the boat to take a tremendous pounding. Heavy objects could break loose and become veritable battering rams. The violent action of the hull could cause serious falls within the boat. Injuries caused at this time are most difficult to treat because of the boat's unpredictable and violent motion. The propeller is alternately submerged and out of the water, causing the engine to be loaded one moment and racing wildly the next. In this condition, the boat, her crew, and all the boat's gear are under extreme stress and steps must be taken immediately to reduce this stress.

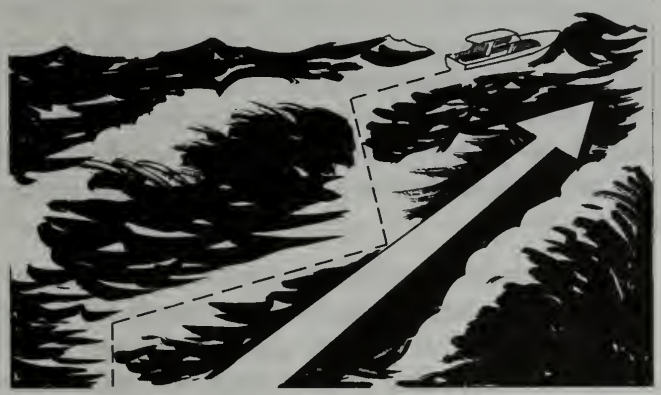
The first thing to do is slow down. Many inexperienced boatmen, caught in their first storm, are unable to resist the temptation to run helter skelter for the nearest port. This would have been an excellent idea before the storm arrived, provided a safe harbor were near enough to reach in time. But now, it is too late! By slowing down, the bow will tend to lift with the waves, as the natural force of buoyancy is again allowed to function. Take the seas slightly off the bow, preferrably at an angle approaching 45°. This will cause the boat to roll and pitch, but it is far easier on both boat and crew than the violent motions of pitching alone. If unable to make headway under these conditions, it is advisable to lay to. Most power craft, if left to their own resources, turn their stern into the wind. This is patently unacceptable in these circumstances, so it will be necessary to use enough power to keep the bow up into the wind, adjusting the speed so that you will be making neither headway nor sternway. If the storm is of long duration, fuel may become a real problem. If this causes concern, it might be best to fall back on a sea anchor. The sea anchor should be securely attached to the rode and the bitter end of the rode should be secured to a bow bitt or cleat *before the sea anchor is set out.* A trip line should be tied to the cone end of the sea anchor, to facilitate its retrieval when necessary. The sea anchor is hauled in backwards by pulling in the trip line. When the sea anchor is set out, the boat will fall back on the line, and the bow will be held into the wind. This may not be very comfortable, but it is the best you can do under the circumstances. Depending on the size of the sea anchor, the drift will be drastically reduced. Try to keep the center of gravity as low as possible by keeping all persons down or near the bottom of the boat. This will make the boat more stable and reduce the chance of capsizing.



3-21 Use of a Sea Anchor

Running in a Beam Sea

Running in a beam sea or "in the trough," as it is commonly called, is an acceptable procedure only under conditions of comparative calm. In a beam sea, the waves are acting directly on the vessel's sides (coming from abeam) and, in rough water, could roll some boats over on their side. If the required course is laid so that you are in the trough and the action of the boat becomes excessive, it might be best to change course slightly to take the seas off the bow or quarter. In order to make the desired landfall it may be necessary to sail a "zig-zag" course, taking the seas off the bow for awhile, then off the quarter. The distance travelled over the water will be longer and your time of arrival will be later, but this change of plan is highly preferrable to a change of plan occasioned by capsizing at sea with all hands ending up in the water.

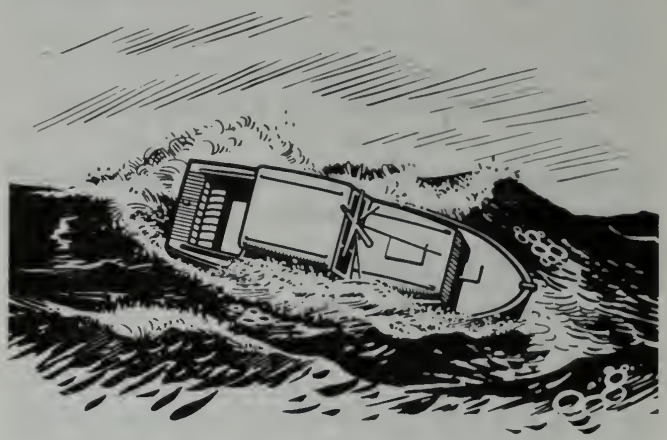


3-22 Zig-Zagging Through Heavy Seas

Running Before the Sea

When a vessel sails in the same direction that the seas are running, it is running before the sea or running in a following sea. On the high seas, a following sea is usually no more than a nuisance. Precise attention to the rudder is required, as the turning action of the hull appears to be more lively and difficult to control. Inexperienced boatmen in their first following sea, tend to overcontrol, with the result that they find themselves wandering all over the ocean.

In shallow bays and large shallow lakes, following seas often build up to the point where it becomes extremely dangerous for small craft. This danger is confined principally to power craft, which usually have large transom areas. Sailing vessels and craft with "double ender" hulls generally experience little difficulty in following seas because of their streamlined underwater shape. The force of the water, acting on the relatively large non-streamlined transom of a power cruiser can cause the boat to yaw wildly from side to side. On some boats, the rudder and propeller can be lifted clear of the water as the stern is picked up by an approaching wave. If the boat is yawing at the time the stern is lifted clear of the water, the boat is completely out of control and could be thrown broadside into the trough and rolled over by the next wave. This is known as going into a broach and should be avoided at all costs.

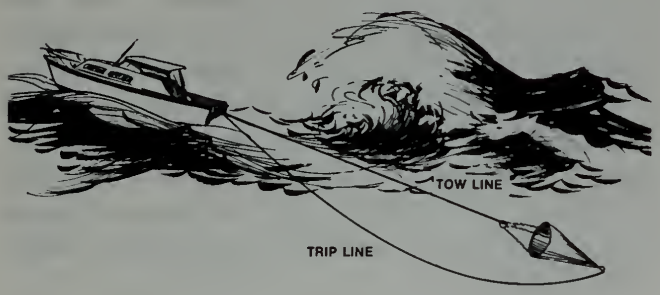


3-23 Broaching

The secret of avoiding a broach is to keep yawing under control at all times. It is important to keep sideways motion to a minimum. This can be accomplished only when the rudder is in the water. The rudder can be kept "wet" by slowing down as the wave approaches the stern and allowing the wave to pass under. The rpm's are then increased slightly until the next wave approaches the stern. rpm's are again reduced long enough to let the next following wave pass under. By judicious use of the throttle and the rudder, yawing can be kept to a minimum. It is important to remember that a yaw can quickly become a broach. Once the broach has started, it is almost impossible to stop.

At this point, one might arrive at the conclusion that running before the sea is a lot of hard work. The fact is that it *is* a lot of hard work. Both the throttle and the rudder must be tended constantly. In a very

heavy following sea, rudder action has been known on occasion to become reversed. Hard right rudder, in these circumstances could send the stern to the right instead of to the left. Under conditions as extreme as this, a heavy line or small sea anchor



3-24 Drogue Used with Following Seas

trailed far astern will help to "nail the stern down" and make the yawing tendency easier to control.

Control of the engine rpm's in a heavy following sea cannot be over-emphasized. Unless the boat is slowed down appreciably as the wave approaches the stern, the vessel will be picked up by the wave and may find itself racing down the forward face of the wave at a greatly increased speed. While this might seem exciting, it could become *too* exciting as the boat races forward and plows into the trough, burying the bow well under in the process. The following wave might well pick up the stern and, with the bow deeply set in the water, flip the boat end over end. This is known as pitchpoling and is extremely dangerous. It is a sad fact that either a broach or a pitchpole has an air of finality about it. The usual result of either is loss of life and property. Needless to say, either can happen instantly in a strong following sea and makes running before the sea potentially the most dangerous point of cruising.

Impaired Visibility

When the subject of impaired or restricted visibility is brought up, most boatmen immediately think of fog. While it is true that fog is the most common impairment to visibility, other conditions such as heavy rain, sleet, hail and snow also fall within this category. The techniques for cruising in im-

3-25 Pitchpoling

paired visibility are common to all of these conditions. For convenience of the author (if for no better reason), we will include all of the foregoing conditions under the general term "fog." Consequently, when we consider fog, we will be inferentially including heavy rain, sleet, hail and snow. On second thought, and in deference to our modern civilization with its effects on our atmosphere, we will also include "heavy smog" in our general classification of "fog."

The first and most obvious rule for safe boat operation in conditions of impaired visibility is not to go out on the water in the first place. If it's too foggy to see, it follows that it is too foggy to cruise. Fog has a habit of burning off eventually and the boatman is well advised to be patient until the visibility improves a bit. The inexperienced boatman, caught out on the water when these conditions close in, will find himself in a whole new world. If it's his first time in a real "pea soup" fog, he will find himself struggling mightily with the temptation to panic.

Even if the fog closes in rapidly, the impending condition can generally be observed for a short time beforehand. This time should be employed in making an accurate determination of the vessel's position. In the section on Plotting we will learn how to do this, but at this time we emphasize the need for determining a position as accurately as possible. Also, if a cruise log has not been maintained up to this point, it is an excellent idea to start one now. If you don't have a log book, the back of an

envelope or the back page of your engine manual will do. Record the compass heading, the speed (as accurately as possible) and the *time*. Unless you know where you were at the time the fog closed in, you will have absolutely no idea where you are at any subsequent time. Further, unless you know in what direction you are heading and how fast (or slow) you are cruising, you will have absolutely no idea where you are going or when you might get there.

Today, many vessels are equipped with radar. Almost all commercial vessels and many pleasure craft now have this equipment. The owner of a boat not equipped with radar can increase his own margin of safety in fog by rigging a radar reflector as high as possible above the hull. A radar reflector is made of thin light-weight metal sheets or fine-mesh metal screen arranged in three mutually perpendicular planes. These reflectors can be purchased commercially or they can be homemade. They are usually constructed so they can be folded flat for easy storage. If the area of each plane is only two feet square the device will reflect a radar image which is comparable to that of a medium sized steel vessel. By placing the radar reflector as high as possible on a mast or in the rigging, vessels equipped with radar will be able to detect the presence of your boat in the fog. This greatly increases your margin of safety.

With your position determined and the log entered you are as ready for the fog as you will ever be. As soon as things close in, slow down. Your speed will be determined by the visible distance. The law requires that you be able to stop in not more than one half of your visible distance. In theory, if all fogbound vessels could stop in half of their distance of visibility, there would be no collisions in fog. For instance, if the visibility were 500 feet, and two vessels on a collision course were to sight each other at 500 feet, each would be able to stop in less than 250 feet. Granted, the vessels would come precariously close—but they would not collide!

Regardless of weather conditions, the law requires that you maintain an efficient watch at all times when you are underway. This becomes more important than ever in a fog. A lookout should be posted on the bow, or as far forward as possible. The bow lookout should be as far removed from the engine noise as possible so that he will be able to hear other sounds around him. Since the fog has deprived all hands from the use of their eyes in the navigation of the vessel, great dependence must be placed on the use of their ears. In extreme cases, it will become necessary to stop the engine frequently to afford all hands a series of silent listening periods.

It might be well to mention that the behavior of sound travelling through fog is most deceptive and unpredictable. In heavy fog, sound has been known to travel long distances and "skip" large areas in the process. A bell or horn, for instance, has been heard clearly a mile away and not heard at all at a distance of 100 yards. Further, when the sound is heard, it can often be interpreted as coming from more than one direction. If the sound is faint, it could appear to come successively from all points of the compass. To compound this even further, our ears are not directionally oriented. Whether we realize it or not, the average human being has grown accustomed to depending on his eyes as an aid to determine the direction from which a sound is coming. Those of you who do not believe this, are invited to try a simple experiment. Stand upright and close your eyes tightly. (Better still, put on a blindfold, since this will keep you from peeking.) Ask someone to snap a pair of coins directly in front of you or directly behind you. Have him do this a few times, both front and back. You will discover, to your surprise, that you will not be able to tell with certainty whether the sound was coming from in front or from behind. And so it is in fog—you must depend on your ears and your ears are not very dependable. However, there are several ways of aiding the directional ability of your ears. One way is to cup your hands behind both ears and then turn your head until the sound is loudest. You are then looking in the direction of the sound. Another way is to place the small end of a megaphone up to one ear, plug the other ear and turn your head until the sound is loudest. The sound is then coming from the direction the megaphone is pointing.

According to law, you must sound proper fog signals on the whistle. This becomes quite an accomplishment if you don't have a whistle. Vessels under 16 feet must sound fog signals even though the law does not specify that a whistle must be carried aboard. Accordingly, if your boating

area is plagued by foggy seasons you should have a whistle (and a bell, as we shall see later) even if your craft is less than 16 feet long. Your whistle signals warn others of your presence. Since all craft are similarly bound to sound fog signals, their signals should warn you of their presence. Upon hearing the fog signal of another vessel, stop immediately and do not start again until you have determined to your full satisfaction that it is safe to proceed. Other sounds that may be heard are fog horns of sailboats, fog horns of lighthouses, bells, sirens, diagraphm horns, the sounds of breakers and other land sounds. Identification of the sound is important as it could possibly be related to an object found on your chart. For instance, a boatman caught in a real "pea souper" off the coast of Southern California, exchanged whistle signals with the Los Angeles Lighthouse for over thirty minutes before he came to the realization that this was, in fact, a lighthouse and not another vessel!

Depending on the depth of the water and the configuration of the shore, an anchor could be lowered from the bow and allowed to hang straight down with sufficient cable out to engage the bottom before the boat runs up on the shore. If you have a radio direction finder aboard and if you have become proficient in its use (it's too late to learn now), it can be of great help in determining your position and in "homing in" on the radio signal. A word of caution to those using this "homing in" technique. Be sure to *stop* before you arrive at the transmitter. Many radio beacons are situated on the ends of breakwaters or piers and many hapless boatmen have "homed in" on these aids with such precision that they smashed right into the pier or ended up holed on a rocky breakwater.

If possible, the best thing to do in a heavy fog is to get well clear of channels and shipping lanes and lower the anchor. When you anchor, you are not underway. However, you are required to sound proper anchor signals when anchored in a fog. Anchor signals are sounded on a bell. Here again, if your boat is less than 26 feet long, you are not legally required to have a bell aboard. In the chapter on *Rules of the Road*, you will study the whole subject of right-of-way, sound signals and fog signals. These rules differ according to where you do your boating. Your instructor will advise you concerning which set of rules apply to your waters. However, the forgoing comments apply to all waters since they are related strictly to the use of common sense.

Running Narrow Inlets

No text on the art of seamanship and safety would be complete without a few words concerning the running of narrow inlets. Many rivers and coves are connected to the sea by narrow inlets. While no two inlets are alike, they have a lot in common. Shoaling is not gradual as it is along most coasts. At the mouth of most narrow inlets shoaling is quite rapid and it is usually confused by bottom irregularities known as sand bars with deeper pools in between.

As the waves approach narrow inlets, their height increases rapidly and breakers form over the shallowest areas, indicating the location and (to some extent) the size of the sand bars. Further, these sand bars are constantly shifting, thus thwarting all attempts to define the limits of the navigable channel by the use of buoys. Every narrow inlet in existence has its own peculiarities and it is here more than anywhere else that local knowledge and intimate familiarity with existing conditions come into play.

It is not possible to learn the techniques of running narrow or breaking inlets from the printed page. Anyone who has ever had the experience of shooting a "hair raiser" will agree with this statement. Narrow inlets come in all shapes and sizes. Some are reserved only for experts even under the best of conditions. Others present only minimum difficulty at best and require a high degree of skill only under the worst of sea conditions. In all narrow inlets, the water is confused and irregular and no prudent boatman would attempt his first run in an unfamiliar inlet without having a "native" aboard to point out known hazards and indicate the areas where the safe channel could most probably be found.

One point to remember when contemplating running a narrow inlet is that you may be required to use bursts of high power to maintain the proper attitude in relation to the seas. This would automatically rule out sailboats (even sailing auxiliaries) and low powered displacement-hull power craft. These types of vessels do not have the necessary quick re-

sponse to run anything but the mildest form of narrow inlet.

While standing off the inlet, prepare a sea anchor or drogue. Use a heavy line for the drogue and be certain that a smaller trip line is attached to the narrow opening. Having determined (by observation) the cadence of the waves, select a small one and run up onto its back surface. The drogue is streamed astern *by the trip line*, ready for use. As the wave moves forward you must maintain your position exactly on the back of the wave. Set the drogue by *letting out* the trip line if you feel the boat is moving toward the crest of the wave. Use bursts of high power if you feel the boat sliding backward into the trough. Maintain your position on the wave until it eventually breaks ahead of your boat. Trip the drogue (if it is still set) and apply full power as you enter the turbulent water. As calmer water is reached, slow down and haul in the drogue by the trip line.

Do not attempt to tow a dinghy astern of your boat while entering a breaking inlet. It can only cause trouble. If possible, the dinghy should be brought aboard and secured bottom up. If this is not possible it might be better to abandon the dinghy and attempt to retrieve it later.

Conclusion

In conclusion, use good common sense when it comes to deciding whether or not you should use your boat when the wind and sea are increasing in velocity and size. If there is the least doubt in your mind, decide against it. Strangely enough, the more a man goes to sea, the greater respect he has for it. Don't tempt fate. Don't take chances on becoming another statistic. The sea has always seemed mysterious. Let the professional seaman seek out its mysteries—he is far better equipped for it.

CHAPTER 4

Legal Requirements

Introduction

The Congress of The United States has recognized the need for safety in boating and has enacted into law certain basic requirements for motorboats. In addition, there are numerous state and local regulations which amplify the federal requirements. As in all other areas of our society, ignorance of the navigation laws does not exempt you from prosecution if you violate them. You must become aware of your responsibilities on the water and equip your craft according to federal and state requirements.

This chapter deals with federal laws and regulations applicable to boats and boatmen. State and local requirements vary so much across the country that it is impossible to cover them in this chapter. You can obtain information concerning these from the nearest state or local boating law enforcement agency.

Numbering of Vessels

Boats propelled by machinery and operated on the navigable waters of the United States must be numbered, regardless of length and whether fitted with inboard or outboard engines.

This numbering requirement excludes boats used exclusively for racing and vessels documented as yachts. Other exceptions include public vessels, state and municipal vessels and ships' lifeboats. Vessels that have a valid temporary certificate may operate without displaying the registration number on the bow while awaiting issuance of a permanent certificate.

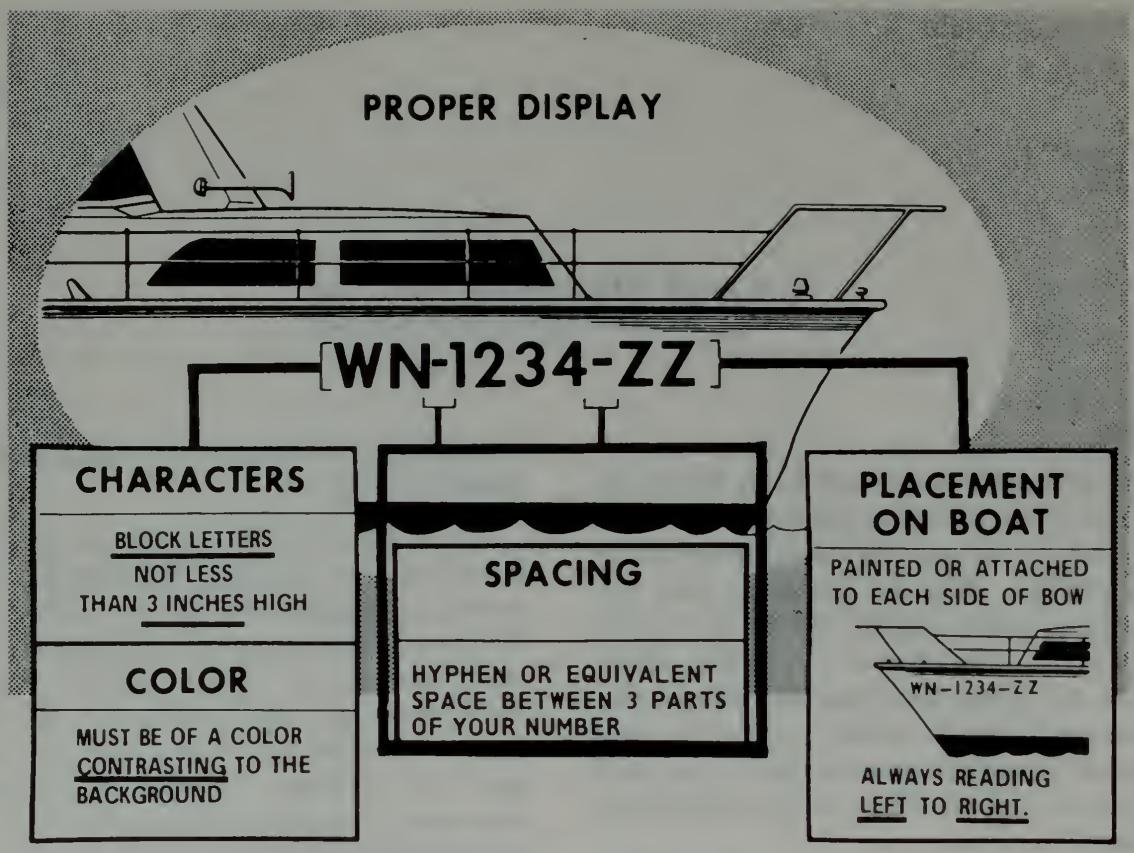
In general, the term "navigable waters of the United States" refers to waters which provide a "road" for transportation between two or more states or to the sea.

Under the Federal Boating Act of 1958, most states have assumed this numbering function. Their systems are compatible with the federal system. If you intend to operate principally on waters in a state which has received federal approval of its numbering system you must determine that particular state's requirements. The state has jurisdiction and may, for example, require all pleasure craft, regardless of type of waters, to be numbered. For information regarding individual states with approved systems, consult your marine dealer, the Coast Guard, the Coast Guard Auxiliary, or the State Boating Law Administration.

If your boat must be numbered, the place of application depends upon the waters of principal use. Where these waters are within a state that has a federally approved numbering system, application is made in accordance with that state's instructions.

When a boat is used principally on ocean or gulf waters, the place where it is normally moored becomes the determining factor in where the application is made. If the state where the boat is moored has a federally approved system, application is made to that state. When the state system has not been federally approved, application is made to the Commandant (G-BD), U.S. Coast Guard, Washington, D.C. 20590. However, most states have enacted numbering laws approved by the federal government.

The number assigned by the certificate is to be painted on or attached to both bows of the vessel and no other number is to be displayed in this area. Numbers are to read from left to right, to be of block character, of contrasting color to the back-



4-1 Proper Number Placement

ground and not less than three inches in height. Between the prefix, the numerals, and the suffix, there must be a hyphen or space equal to any letter except "I" or "1."

The number shall not be placed on the obscured underside of a flared bow where the angle is such that the number cannot be easily read. When the vessel configuration is such that the number cannot be so placed on the bow, it will be placed on the forward half of the hull or on the permanent superstructure located on the forward half of the hull, as nearly vertical as possible, and where easily observed. If the above will not provide ready identification, the number may be mounted on a bracket or fixture firmly attached to the forward half of the vessel.

Sales and Transfers

Boat numbers and Certificates of Number are not transferable from person to person, nor from boat to boat. This number stays with the boat unless the state of principal use is changed. When numbered by the Coast Guard, a new application with a $6.00 fee must be filed by each owner for every boat (except dealers) with the Commandant (G-BD), U.S. Coast Guard, Washington, D.C. 20590.

Documenting of Vessels

Under navigation laws administered by the U. S. Coast Guard, a vessel of 5 net tons or over owned by a citizen of the United States and used exclusively for pleasure may be documented as a yacht.

The principal privileges are:

(a) Authority to fly the yacht ensign.
(b) Provision for recording and retaining copies of mortgages, bills of sale, and other instruments of title with the U. S. Coast Guard. Mortgages which are so recorded may, upon compliance with the applicable requirements, become preferred mortgages, thus giving additional security to the mortgagee.

A documented yacht must display her name and hailing port on some conspicuous portion of the hull, usually the stern, and her official number and net tonnage must be carved or otherwise permanently marked on her main beam.

Sales to Aliens

Under Federal law, the sale, transfer, mortgage, or lease by a U. S. citizen to an alien of a vessel of more than 65 feet in length and/or designed for propulsion by an engine or engines totalling more than 600 horsepower, must be specifically approved by the Maritime Administration.

The same stipulation applies to the sale, transfer, mortgage, or lease (to an alien) of any vessel presently documented or last documented in the United States, regardless of its length or specified horsepower.

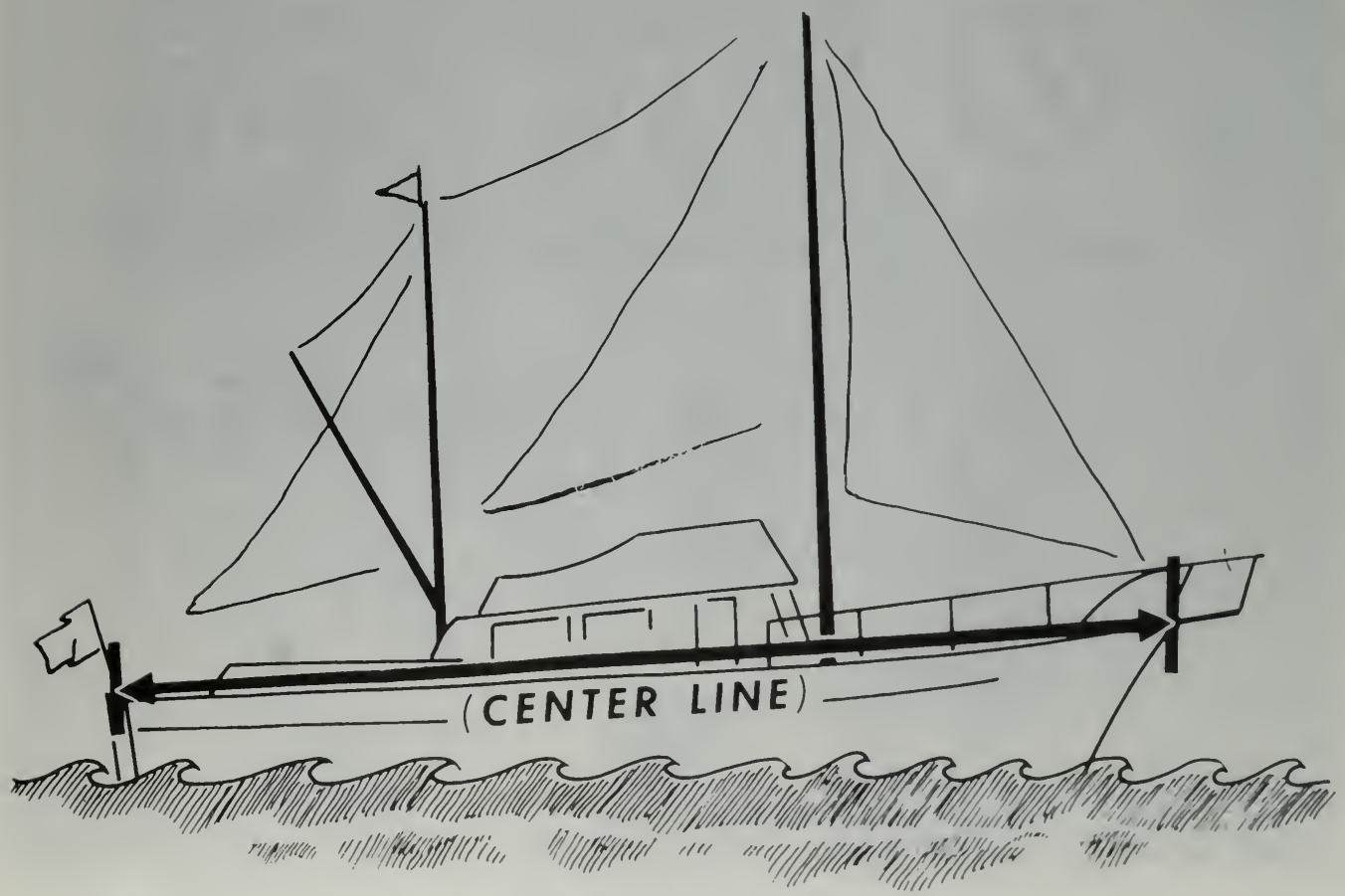
Specific advance approval by the Maritime Administration is also necessary for the sale of any vessel to a citizen or resident of certain Communist-controlled countries.

For approvals or further information, communicate with the Foreign Transfer Branch, Office of Ship Operations, Maritime Administration, Washington, D. C. 20235.

Length of Motorboats

The federal government has, through the Motorboat Act of 1940, as amended, set forth minimum equipment for different lengths of boat. Before you can determine your boat's needs to conform with the requirements of federal law, you first have to accurately determine the length of the boat. "Motorboat" means any vessel 65 feet in length or less which is propelled by steam. The word "motorboat," also means a boat temporarily or permanently equipped with a motor and, although few and far between, a boat propelled by steam.

For determining "official length", the length is measured from end to end over the deck excluding sheer. This means a straight line measurement of the



4-2 Measuring the Boat

overall length from the foremost part of the vessel to the aftermost part of the vessel, measured parallel to the centerline. Bow sprits, bumpkins, rudders, outboard motor brackets, and similar fittings or attachments are not to be included in the measurement. Length is stated in feet and inches.

After determining your boat's length, the next step is to equip it with at least the minimum requirements by the law. It is important to remember that this equipment is the minimum required to be on board your boat to conform with federal law.

All motorboats are required to carry up to six different items of equipment: fire extinguishers, personal flotation devices, flame arrestors, ventilation devices, bells, and whistles.

Lights

By day, a vessel's course, change of course or progress on her course is fairly obvious. By night, practically nothing can be determined about another vessel unless the vessel is lighted according to the rules. As with the rules for maneuvering, the provisions for lights vary according to the place, the size of the vessel and her use. Lights for vessels will be discussed in Chapter V, *Rules of the Road.*

Fire Extinguishers

Fire extinguishers are classified by letter and roman numeral according to their size and the type of fire they are designed to put out. The letter indicates the type of fire: "A" for combustible solids;

4-3 Equipment for boats less than 16 feet in length.

4-4 Equipment for boats 16 feet to less than 26 feet in length.

4-5 Equipment for boats 26 feet to less than 40 feet in length.

4-6 Equipment for boats 40 feet to not more than 65 feet in length.

"B" for flammable and combustible liquids; "C" for electrical fires and "D" for combustible metals. Motorboats are required to have either hand portable or semi-portable units capable of extinguishing fires involving flammable liquids and grease (class "B" fires). The table below makes it easy to understand the classifications you will use:

Classification (type — size)	*Foam*	*Carbon Dioxide*	*Dry Chemical*	*Freon*
B-I	1¼ gals.	4 lbs.	2 lbs.	2½ lbs.
B-II	2½ gals.	15 lbs.	10 lbs.	—
B-III	12 gals.	35 lbs.	20 lbs.	—

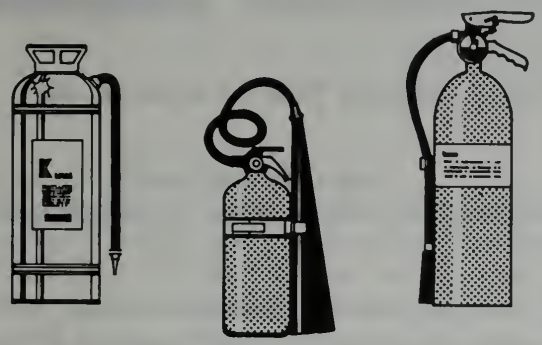
To meet equipment requirements, portable fire extinguishers must be Coast Guard approved. Portable fire extinguishers bearing the "Marine Type" label of Underwriters' Laboratories Inc., are approved for use on motorboats. Example: "Marine Type, USCG Type B, Size 1, Approval No. 160. 028/EX. . . ."

For current listings of marine type portable fire extinguishers, consult the Fire Protection Equipment List published by the Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago, Illinois.

Most fire extinguishers manufactured prior to 1 January 1965, do not have the Coast Guard approval number on the nameplate. When a fire extinguisher does not show the Coast Guard approval number, the nameplate should be checked against the listing in CG-190, Equipment Lists at Coast Guard Marine Inspection Offices, or Underwriters' Laboratories, Inc., Fire Protection Equipment List. To be acceptable by the Coast Guard for use, they must be in good and serviceable condition.

If there is doubt about the approval status of any fire extinguisher, you should contact the nearest Coast Guard Marine Inspection Office.

You should make frequent checks to be sure your extinguishers are in their proper stowage brackets and undamaged. Cracked or broken hose should be replaced and nozzles should be kept free of obstructions. Extinguishers having pressure gauges should show pressure within the designated limits. Locking pins and sealing wires should be checked to assure that the extinguisher has not been used since last recharge. Extinguishers should never be tried merely to see if they are in proper operating condition because in many cases the valves will not properly reseat, thereby resulting in a gradual discharge. A discharged extinguisher should be recharged at the first opportunity.



4-7 Typical Fire Extinguishers

The following tests and inspections should be made by qualified persons:

Foam

Once a year discharge the extinguisher. Clean the hose and inside of the extinguisher thoroughly. Recharge and attach a tag indicating the date of servicing.

Carbon Dioxide or Freon

Twice a year weigh the cylinder and recharge if the weight loss exceeds 10% of the weight of the charge. Inspect hose and nozzle to be sure they are clear. Inspect the lead seals on the operating levers to insure they are not broken. Attach a tag to indicate when the extinguisher was serviced or inspected.

Dry Chemical

With visual pressure indicator

Regularly check the pressure indicator to insure the extinguisher has the proper amount of pressure. Occasionally invert the extinguisher and shake it to insure that the powder has not packed and caked due to vibration. Check the nozzle to insure that there is no powder in it; if there is, weigh the extinguisher to insure that it has a full charge. Check the seals to insure that they are intact.

Without indicator

Once every six months the extinguisher must be taken ashore to be checked and weighed. If the weight is ¼ ounce less than that stamped on the container it must be serviced. The seals indicating that it has not been tampered with must be intact. If there is any indication of tampering or leakage such as powder in the nozzle, the extinguisher must be serviced. All servicing must be indicated by the servicing station on an attached tag.

Fire Extinguisher Requirements

If, owing to the nature of its construction, a boat will tend to trap explosive vapors, it is required to carry a fire extinguisher. There is increased possibly of explosion if any of the below listed conditions exist. Motorboats less than 26 feet in length having one or more of these areas are required to carry a fire extinguisher.

1. Closed compartments under thwarts and seats wherein portable tanks may be stored.
2. Double bottoms not sealed to the hull or which are not completely filled with flotation material.
3. Closed living spaces.
4. Closed stowage compartments in which combustible or flammable materials are stowed.
5. Permanently installed fuel tanks.

The conditions numbered below do not, by themselves, require fire extinguishers on motorboats less than 26 feet in length:

1. **Bait wells.**
2. **Glove compartments.**
3. **Buoyant flotation material.**
4. Open slatted flooring.
5. Ice chests.

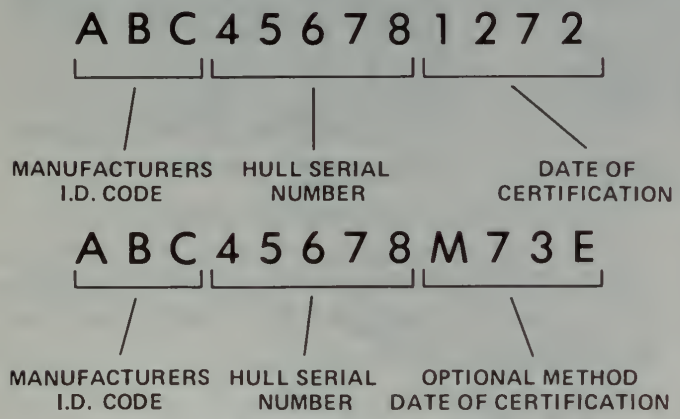
All motorboats 26 feet or greater, and those motorboats less than 26 feet which are required to be equipped with fire extinguishers, must be equipped according to the following table:

MINIMUM NUMBER OF HAND PORTABLE FIRE EXTINGUISHERS REQUIRED

Length of vessel	No fixed system in machinery space	Fixed fire extinguishing system in machinery space
Less than 16′	1 B-I	None
16′ to less than 26′	1 B-I	None
26′ to less than 40′	2 B-I or 1 B-II	1 B-I
40′ through 65′	3 B-I or 1 B-II and 1 B-I	2 B-I or 1 B-II

Hull Identification Number

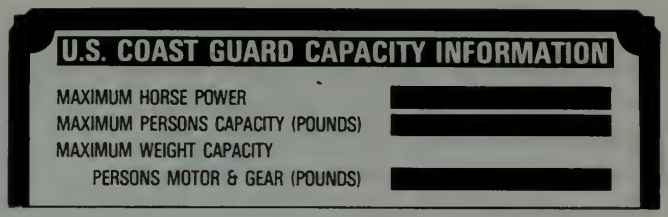
A hull identification number must be displayed on all recreation boats the construction of which began after October 31, 1972. The number consists of 12 characters no less than one-fourth of an inch in height and must be affixed to the outboard side of the transom or, if there is no transom, to the outermost starboard side at the end of the hull that bears the rudder or other steering mechanism. The hull identification number must be affixed above the waterline of the boat in such a way that alteration, removal, or replacement would be obvious and evident. Additional characters may be displayed after the hull identification number if they are separated from the hull identification number by a hyphen.



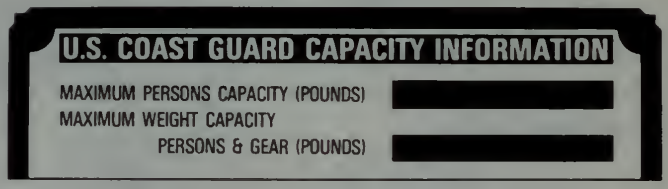
4-8 Hull Identification Number

Display of Capacity Information

All monohull recreational boats less than 20 feet in length the construction of which began after October 31, 1972, except sailboats, canoes, kayaks, and inflatable boats, must have a legible capacity marking permanently displayed where it is clearly visible to the operator when he is getting the boat underway. The information required to be marked must be displayed in the following manner:



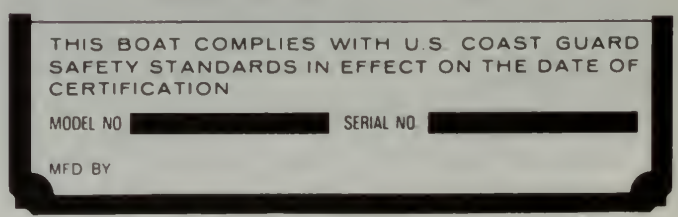
4-9 Capacity Plate for Outboards



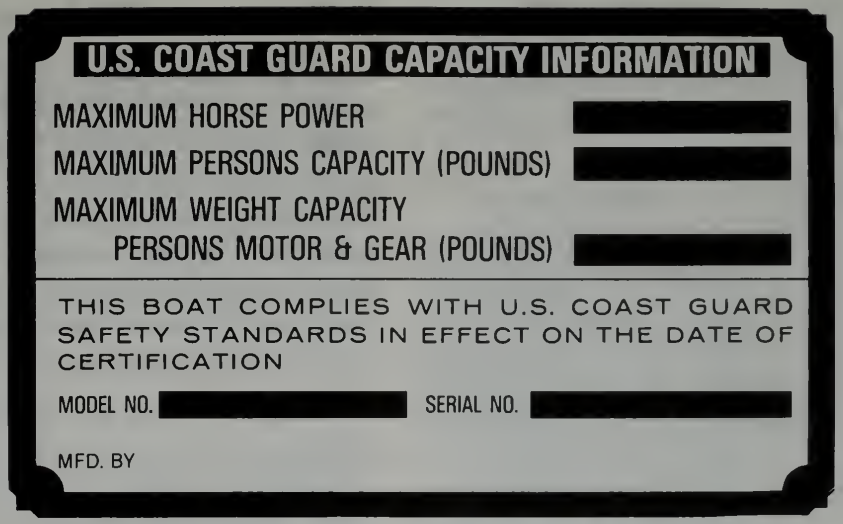
4-10 Capacity Plate for Inboards, etc.

Manufacturer Certification of Compliance

A certification of compliance label must be affixed to all monohull boats less than 20 feet in length except sailboats, canoes, kayaks, and inflatable boats construction of which began after 31 October 1972. Each label must contain (1) the name and address of the manufacturer who certifies the boat or associated equipment and (2) the words "This ('Boat' or 'Equipment') complies with U.S. Coast Guard Safety Standards in effect on the Date of Certification. Letters and numbers must be no less than one-eighth of an inch in height. The certification of compliance label may be affixed at any easily accessible location on the boat or associated equipment. This label may, at the manufacturer's option, be combined with the capacity plate.



4-11 Certificate of Compliance



4-12 Combination Capacity Plate and Certificate of Compliance

Personal Flotation Devices

As of 1 October 1973, a new Federal personal flotation device (PFD) regulation became effective. The new law requires that (1) all recreational boats less than sixteen (16) feet in length, including sailboats and rowboats, and all kayaks and canoes, carry at least one Type I, II, III, or IV PFD for each person on board, and (2) all recreational boats sixteen (16) feet or over in length, including sailboats and rowboats, carry at least one Type I, II, or III (wearable) PFD for each person on board *and* one Type IV (throwable) PFD in each boat.

The new regulation defines the various types of PFD's as follows:

Type I – A Type I PFD is a Coast Guard approved device designed to turn an *unconscious* person in the water from a face downward position to a vertical or slightly backward position, and to have more than 20 pounds of buoyancy. This is the familiar collar-type lifejacket, bulky and less wearable than other PFD types, but designed to keep the wearer afloat for extended periods of time in rough water. Type I PFD's are recommended for off-shore cruising. They are acceptable for all size boats.

Type II – A Type II PFD is a Coast Guard approved device designed to turn an *unconscious* person in the water from a face downward position to a vertical or slightly backward position, and to have at least 15.5 pounds of buoyancy. This is a more wearable device than the Type I and is recommended for closer, in-shore cruising. Type II PFD's are also acceptable for all size boats.

Type III – A Type III PFD is a Coast Guard approved device designed to keep a *conscious* person in a vertical or slightly backward position. Like the Type II PFD, Type III must have at least 15.5 pounds of buoyancy. However, it has a lesser turning ability than either Type I or Type II. Type III PFD's are recommended for in-water sports, or on lakes, impoundments, and close in-shore operation. They are acceptable for all size boats.

Type IV – A Type IV PFD is a Coast Guard approved device designed to be *thrown to a person in the water and not worn.* It must have at least 16.5 pounds of buoyancy. Type IV PFD's are acceptable for boats less than 16 feet in length and canoes and kayaks, and at least one Type IV PFD is required for boats 16 feet and over in length.

All Coast Guard approved personal flotation devices bear markings indicating the manufacturer, the type, and an approval number. However, since the above type designations were adopted in 1973,

there are many kinds of Coast Guard approved PFD's in existence which are not marked as "Type I, II, III, or IV." The following "conversion" table gives equivalent "type" information for previously existing devices.

Number on Label	Devices Marked	are Equivalent to
160.002	Life preserver	Performance Type I personal flotation device
160.003	Life preserver	Performance Type I personal flotation device
160.004	Life preserver	Performance Type I personal flotation device
160.005	Life preserver	Performance Type I personal flotation device
160.009	Ring life buoy	Performance Type IV personal flotation device
160.047	Buoyant vest	Performance Type II personal flotation device
160.048	Buoyant cushion	Performance Type IV personal flotation device
160.049	Buoyant cushion	Performance Type IV personal flotation device
160.050	Ring life buoy	Performance Type IV personal flotation device
160.052	Buoyant vest	Performance Type II personal flotation device
160.055	Life preserver	Performance Type I personal flotation device
160.060	Buoyant vest	Performance Type II personal flotation device
160.064	Special purpose water safety buoyant devices	A device intended to be worn may be equivalent to Type II or Type III. A device that is equivalent to Type III is marked "Type III Device – may not turn unconscious wearer." A device intended to be grasped is equivalent to Type IV.

All personal flotation devices can have excellent flotation materials, be expertly manufactured and be in serviceable condition without being a good personal flotation device. Why? The proper use of any personal flotation device requires the wearer to know how it will perform. The only way to gain this knowledge is through personal experience. Every person going out on the water in a boat should first understand how to properly fit and wear the personal flotation device intended for his use. He should then understand how the device will react when the wearer and device are in the water. Only then can he be sure he and the device are ready for an emergency which would cause him to leave the boat. Children, especially, require this practice. Child size devices are acceptable only for persons weighing less than 90 pounds.

Life Preservers (Type I PFDs)

Life preservers will last for many years if they are given reasonable care. They should be dried thoroughly before being put away and should be stowed in a dry, well-ventilated place. Do not stow in the bottom of lockers or deck storage boxes where moisture might accumulate. Frequent airing and drying in the sun is also recommended. Life preservers should not be tossed about haphazardly, used as fenders or cushions, or otherwise roughly treated.

Life preservers are most often of the kapok type, although buoyant fibrous glass, cork, balsa wood, and unicellular plastic foam are used. They are either jacket or bib design.

The jacket type is constructed with pads of buoyant materials inserted in a cloth covering. This covering is fitted with the necessary straps and ties.

Bib type life preservers are constructed of unicellular plastic foam with a vinyl-dip surface or cloth cover. They are fitted with an adjustable strap. Adult and child sizes are available. All Coast Guard approved life preservers (Type I) are required to be Indian Orange colored.

The jacket type life preserver should be put on the same as a coat with all ties and fasteners secured to obtain a snug fit. When the bib type is worn the body strap should be drawn snugly.

All life preservers are required to be ready for use and readily accessible. This means they should be ready to be worn without adjustments as well as being within reach. The straps should be adjusted for the person for whom it is intended and the fasteners unhooked to eliminate that step when time is most critical.

4-13 Type I Personal Flotation Device

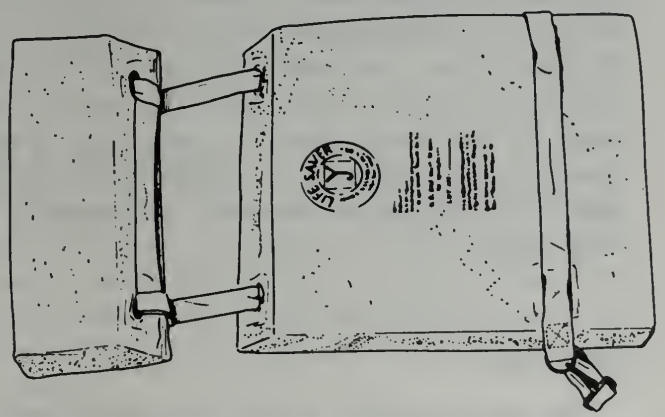
When underway in a small open boat, life preservers should be worn by children and non-swimmers. When rough weather is encountered on any type of boat, or when in hazardous waters, life preservers should be worn by everyone. As a matter of good seamanship and common sense, all *unsatisfactory* lifesaving equipment should be left ashore. Its replacement should be Coast Guard approved equipment. An emergency is no time to conduct an inspection to determine whether or not the equipment is serviceable.

Buoyant Vests (Type II PFDs)

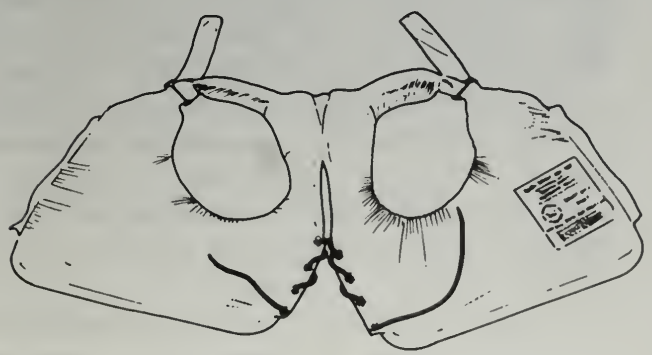
Coast Guard approved buoyant vests are manufactured in several designs. They can be constructed of pads of kapok, fibrous glass or unicellular plastic with cloth covering, with straps and ties attached. The kapok and fibrous glass pads are enclosed in plastic bags. Other models of buoyant vests are made of unicellular plastic foam which has a vinyl-dip coating. They are made in three sizes: adult, child (medium) and child (small), and may be any color.

Buoyant vests are identified by a Coast Guard approval number and the model number which are contained on a label attached to the vest. Vests must be in good and serviceable condition.

As with life preservers, buoyant vests have a variety of adjustable straps which should be adjusted to fit before leaving the mooring. Be sure to make children's adjustments for proper fit, too. Vests should be worn snugly with all ties and fasteners pulled tight and worn by children and non-swimmers when underway in small boats or open construction type craft. They should be dried thoroughly before being put away, and when stowed on board should be in a readily accessible location which is dry, cool, and well ventilated. Buoyant vests should not be tossed about haphazardly, used as fenders or cushions, or otherwise roughly treated.



4-14 Type II Personal Flotation Device



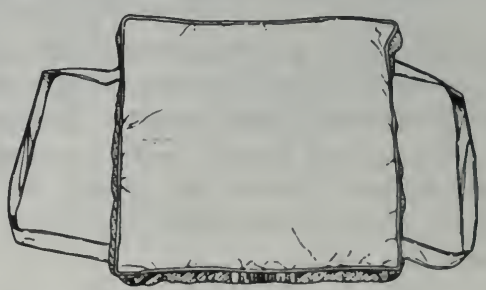
4-15 Type III Personal Flotation Device

Buoyant Cushions (Type IV PFDs)

Buoyant cushions approved by the Coast Guard contain kapok, fibrous glass or unicellular plastic foam, come in a variety of sizes and shapes, may be any color, and are fitted with grab straps. Some unicellular plastic foam buoyant cushions are vinyl-dip coated.

Buoyant cushions are generally more readily accessible since they are sometimes used as seat cushions. However, the kapok or fibrous glass cushions used as seats become unserviceable rather rapidly because the inner plastic envelope may be punctured.

Cushions are usually available in time of emergency. However, they are difficult to hang on to in the water and do not afford as great a degree of protection as a life preserver or buoyant vest. For this reason, buoyant cushions are not recommended for use by children or non-swimmers. The straps on buoyant cushions are put there primarily for holding-on purposes. However, they may also be used in throwing the cushion. Cushions should never be worn on a person's back since this tends to force the wearer's face down in the water.



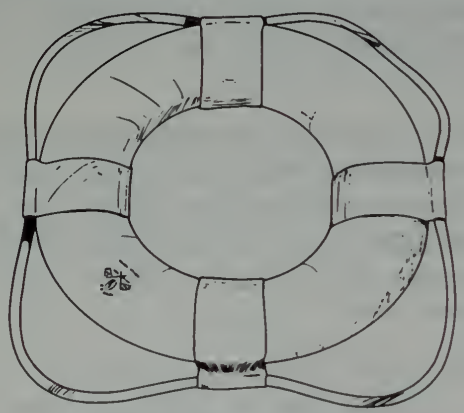
4-16 Type IV PFD (Buoyant Cushion)

Approved buoyant cushions are marked on the side (gusset), showing the Coast Guard approval number and other information concerning the cushion and its use.

Ring Life Buoys (Type IV PFDs)

These personal flotation devices can be made of cork, balsa wood or unicellular plastic foam, and are available in 30, 24, and 20-inch sizes. Their covering is either canvas or specially-surfaced plastic foam. All buoys are fitted with a grab line and may be colored either white or orange.

Approximately 60 feet of line should be attached to the grab rope on the ring buoy. When throwing a ring buoy, care should be taken not to hit the person in the water. Ring buoys should be stowed in brackets topside, readily accessible for emergencies.



4-17 Type IV PFD (Ring Buoy)

Cork and balsa wood ring buoys must bear two markings, the manufacturer's stamp and the Coast Guard inspector's stamp. Plastic foam ring buoys bear only one marking, a nameplate attached to the buoy.

Special Purpose Water Safety Buoyant Devices (May be Type III PFD's)

Approved special purpose water safety buoyant devices are manufactured in many designs depending on the intended special purpose. These include water ski jump vests, hunters' vests, motorboat racing vests, flotation jackets, and others. Additional strength is added where needed for the intended purpose of the device.

The devices are made for either wearing or grasping. Wearing devices are available in adult and child sizes. Their markings include the Coast Guard approval Number E25/160.064/ . . . as well as the special purpose for which the device is intended, instructions for use and maintenance, and other necessary information. The devices intended for grasping also are marked with the wording: *"Warning—Do not wear on Back."*

Ventilation Systems

No foolproof ventilation system has been developed. The efficiency of various shaped cowls and ducts, the location of system components, the capacity of blowers, and the choice of materials are all related to safety. There is no such thing as a ventilation system "approved" by the Coast Guard. There has been, however, a great deal of study and thought, some testing, and years of experience upon which to form recommendations. These lead to the conclusion that, as a minimum, fresh air should be ducted into each engine and fuel tank compartment and dangerous fumes ducted out of the vessel. To create a flow through the ducting system, at least when underway or when there is a wind, cowls (scoops) or other fittings of equivalent effectiveness are needed on all ducts. A wind-actuated rotary exhauster or mechanical blower is considered equivalent and preferred to a cowl on the exhaust duct. To scavenge gases from ventilated spaces and avoid undesirable turbulance within the spaces, at least one inlet duct must be installed to extend to a point at least midway to the bilge, or at least below the level of the carburetor air intake. At least one exhaust duct must extend from the open atmosphere to the lower portion of the bilge. Ducts should not be installed so low in the bilge that they may become obstructed by normal accumulation of bilge water.

Open Boats

The use of gasoline in boats will always present a safety hazard because the vapors are heavier than air and may find their way into the bilges from which there is no escape except through the ventilation systems. In an open boat these vapors may be dissipated through the scouring effect of exposure to the open atmosphere. Open boats are, therefore, exempted from the above ventilation requirements.

All three of the following conditions should be met in order to consider a boat "open":

1. Engine and fuel tank compartments shall have as a minimum 15 square inches of open area directly exposed to the atmosphere for each cubic foot of net compartment volume.

2. There must be no long or narrow unventilated spaces accessible from such compartments in which a flame could propagate.
3. Long, narrow compartments (such as side panels), if joining engine or fuel compartments and not serving as ducts thereto, shall have at least 15 square inches of open area per cubic foot provided by frequent openings along the full length of the compartment formed.

Technical Details

Most boat owners, on learning that fires and explosions of fuels cause more property damage in pleasure boating than any other type of accident, and run a close second to collisions in personal injuries, are anxious to improve the ventilation system on their boats. They want to protect their families, friends and investments by installing a ventilation system that at least meets the safety standards recommended by the boat building industry. To accomplish this the following should be considered and installed if not present.

Intake (Air Supply)

There must be one or more intake ducts into each fuel and engine compartment, fitted with a cowl (scoop), extending from the open atmosphere to a level midway to the bilge (fuel compartment) or at least below the level of the carburetor (engine compartment).

Exhaust

There must be one or more exhaust ducts from the lower portion of the bilge of each fuel and engine compartment to the free atmosphere, fitted with a cowl or an equivalent such as a wind actuated rotary exhauster or a power exhaust blower.

Ducting Materials

For long life and safety, ducts should be constructed of nonferrous, galvanized ferrous, or sturdy high temperature resistant nonmetallic materials, routed clear of and protected from contact with hot engine surfaces.

Positioning of Cowls

Normally, the intake cowl will face forward in an area of free underway airflow, and the exhaust cowl will face aft where a suction effect can be expected. They should be located with respect to each other so as to avoid the pick up of vapors while fueling.

Carburetion Air

Openings in engine compartment for entry of air to the carburetor are additional to the ventilation system requirements.

Ducting Size

There should be no constriction in the ducting system which is smaller than the minimum cross sectional area required for reasonable efficiency.

Small Motorboats

To determine the minimum cross sectional area of the air conduits (cowls and ducting) for motorboats having small engine and/or fuel tank compartments see table 1, which is based on net compartment volume.

Cabin Cruisers and Larger Boats

For most cabin cruisers and other large motorboats, Table 2, which is based on the vessel's beam, is a practical guide for determining the minimum cross sectional area of the air conduits (ducts and cowls).

TABLE I

ONE INTAKE AND ONE EXHAUST SYSTEM			TWO INTAKE AND TWO EXHAUST SYSTEMS
Net Volume (cu. ft.)	*Minimum Inside Diameter for Each (inches)*	*Area (sq. in.)*	*Minimum Inside Diameter for Each (inches)*
Up to 8	2	3	
10	2¼	4	
12	2½	5	
14	2¾	6	
17	3	7	
20	3¼	8	
23	3½	10	2½
27	3¾	11	3
30	4	13	3
35	4¼	14	3
39	4½	16	3
43	4¾	19	3
48	5	20	3

NOTE: Determine gross compartment volume, then determine the volume of tanks, engine and other items in that compartment. The difference is the net compartment volume.

TABLE 2
TWO INTAKE AND TWO EXHAUST SYSTEMS

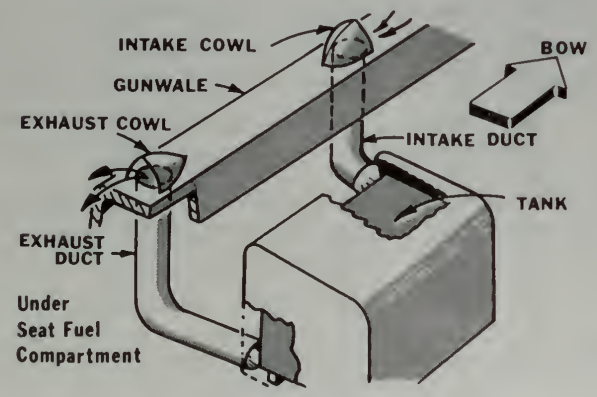
Vessel Beam (feet)	*Minimum Inside Diameter for Each Duct (inches)*	*Area (square inches)*
7	3	7
8	3¼	8
9	3½	9
10	3½	10
11	3¾	11
12	4	12
13	4¼	13
14	4¼	14
15	4½	15
16	4½	16
17	4½	17
18	5	18
19	5	19

General Precautions

Ventilation systems are not designed to remove vapors caused by breaks in fuel lines or leaking tanks. If gas odors are detected repairs are generally indicated. Prior to each starting of the engine, especially on calm days and where a power exhaust system is not installed, the engine compartment should be opened to dissipate vapors which may be present. The smaller the compartment the quicker an explosive mixture of gasoline vapors can be expected to develop.

Play it Safe—Keep Your Boat Free of Explosive Vapors!

Note: Vessels which are intended for carrying more than six passengers for hire are subject to special regulations. Owners should contact the nearest Coast Guard Marine Inspection Office for inspection requirements.



4-18 Ventilation

Example of Ventilation Arrangements On Small Motorboats

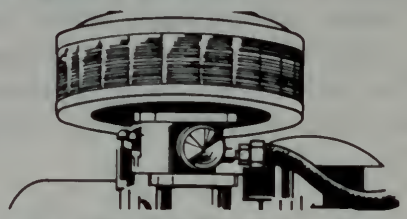
Natural System

The above features provide for ventilation without mechanical assistance. Efficiency is greatest when there is a breeze from forward of the beam, which will normally occur when underway or at anchor, and some of the time when moored. Although less efficient when the wind is abaft the beam, some scouring effect may even then be expected.

Mechanical Blowers

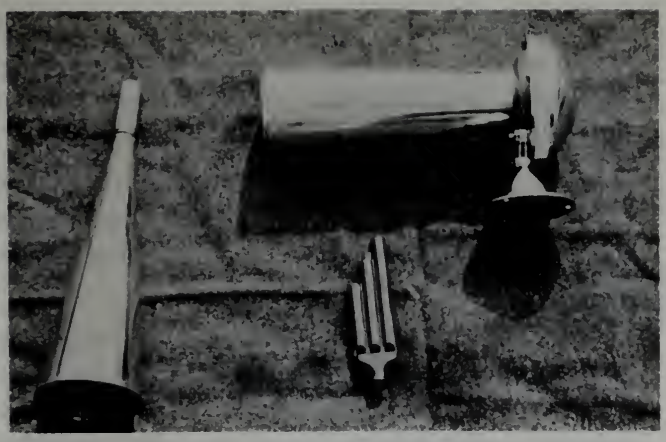
To provide a positive means of exhausting vapors when there is little or no movement of air (calm days) and especially before starting engines when the explosion risk is greatest, mechanical blowers are recommended for engine spaces. It is suggested that ducting separate from the natural ventilation system be installed. Exhaust blowers should be of the sealed or arcless type and, if located within the compartment being ventilated, be as high as possible. Blower fan blades or impellers should be non-sparking and, if installed in the exhaust duct of the natural system, should not interfere with the functioning of the ducts as natural ventilators. Exterior terminations of power exhaust ducts may be fitted with louvered fittings instead of cowls.

Backfire Flame Arrestors



4-19 Backfire Flame Arrestor

Gasoline engines (other than outboard engines) that have been installed since April 25 1940, must have an efficient means of backfire flame control. To be considered acceptable, a Coast Guard approved backfire flame arrestor must be attached to the engine air intake by a flame-tight connection. A gasoline engine to be approved by the Coast Guard, must be equipped with an engine-air and fuel-induction system that prevents backfire flames from reaching the atmosphere outside the vessel in such manner as to endanger the vessel, persons aboard or nearby vessels or structures.



4-20 Whistle and Horns

Whistle or Horn

Whistle signals are required to be given by all boats under certain circumstances. Equipment requirements vary according to the length of the boat.

Less than 16 feet	No whistle required.
16 feet to less than 26 feet	Mouth, hand or power operated, capable of producing a blast of 2 seconds or more duration and audible for a distance of at least ½ mile.
26 feet to less than 40 feet	Hand or power operated, capable of producing a blast of 2 seconds or more duration and audible for a distance of at least 1 mile.
40 feet through 65 feet	Power operated, capable of producing a blast of 2 seconds or more duration and audible for a distance of at least 1 mile.

Note that even though a boat less than 16 feet in length is not required to have a whistle on board, it still must give the proper whistle signals when needed.

4-21 Bell

Bell

Bell signals are required when a vessel is at anchor under conditions of restricted visibility. All vessels 26 feet or greater but not more than 65 feet in length are required to carry a bell on board. No specific size is stipulated but it must be capable of giving a clear, bell-like tone. Even though boats less than 26 feet in length need not have a bell aboard, this does not exempt them from the requirement to give the proper signals if the occasion arises.

Your Responsibility as a Boatman

You are responsible for any damage your boat may cause other craft or for any injuries suffered by your passengers or others. For instance, if you pass close to a cruiser at high speed and your wake rocks this vessel so that the dishes in the galley are broken, you may be held responsible. If this should happen when hot foods are being prepared or served on board the cruiser and someone suffers serious burns as a result of the violent rocking caused by your wake, you may be held liable. You could be summoned into court and equitable civil damages assessed against you. In addition, you might also be cited for operating a motorboat in a reckless manner.

Boating Accident Reports

The operator of any boat involved in an accident must stop, render assistance and offer identification. Reports must be made for any accident which results in death, personal injury (a person loses consciousness or receives medical treatment or is disabled for more than 24 hours), property damage in amount greater than $100, or the disappearance of a person (that indicates death or injury). In accidents involving death or disappearance, the nearest reporting authority must be notified immediately (and in writing within 48 hours); all other accidents must be reported within 5 days.

Boating accident report forms (CG-3865) may be obtained from any Coast Guard office or unit. They must be submitted by the operator to the nearest Coast Guard Officer in Charge, Marine Inspection, unless the operator is required to file an accident report with a state having an approved numbering system. Accident reports furnish information for use in compiling accident prevention data. Information from individual reports will not be publicly disclosed.

Law Enforcement

Coast Guard boarding vessels will be identified by the Coast Guard ensign and personnel will be in uniform. A vessel underway, upon being hailed by a Coast Guard vessel or patrolboat, is required to stop immediately and lay to or maneuver in such a way as to permit the boarding officer to come aboard. Failure to stop to permit boarding may subject the operator to a penalty which may be as much as $100.

The owner or operator of a vessel which is not numbered as required or who fails to file notice of transfer, destruction or abandonment of a vessel or fails to report a change of address, is liable to a penalty which could be as much as $50.

A civil penalty may be imposed by the Coast Guard for reckless or negligent operation, for failure to obey the rules of the road or failure to comply with regulations.

The law also provides for a fine of up to $1,000 and imprisonment of not more than 1 year for the criminal offense of reckless or negligent operation of a vessel which endangers the life or property of any person.

Courtesy Motorboat Examination

As a courtesy to pleasure boat owners and operators, members of the Coast Guard Auxiliary check thousands of boats each year for legal and safety requirements. These members are qualified as Courtesy Examiners under strict requirements set by the Coast Guard and are very knowledgeable in their field. The examinations are performed as a courtesy and only with the consent of the pleasure boat owner. To pass the examination, a vessel must satisfy not only federal equipment requirements but also certain additional safety requirements recommended by the Auxiliary. If the boat passes the examination it is awarded a safety decal which is placed conspicuously on the vessel.

Federal Boat Safety Act of 1971

In August 1971 major Federal legislation, PL 92-75 or the Federal Boat Safety Act of 1971 was enacted into law. This law manifested the mandate given the U.S. Coast Guard by the Congress of the United States to improve recreational boat safety. Federal regulations which are being or have been developed will bring about a number of changes designed to improve boating safety. A few of these changes affecting sections in this chapter are:

a. Establish a new system for numbering boats. The Act requires any vessel, if undocumented, equipped with propulsion machinery of any type, regardless of horsepower, to be numbered.

b. Establish a uniform system for reporting boating accidents. Existing regulations defining reportable accidents and reporting procedures will be changed.

c. Establish specific safety standards which boat manufacturers must follow in the manufacture of boats. These will encompass such areas as capacity, flotation, safe powering and fire and explosion, among others.

d. Establish specific standards of performance for certain associated equipment normally carried by recreational boats.

e. Require a boat manufacturer to report non-compliance with a standard or any defect which creates a substantial risk of personal injury to the public to purchasers of boats by means of a defects notification system.

f. Require that each boat manufactured be assigned a hull identification number.

Regulations have already been issued under the new law and became effective April 17, 1972, requiring the carriage of Coast Guard approved personal flotation devices on all recreational boats.

The law also authorizes a Coast Guard Boarding Officer, when in his judgment continued unsafe use of a boat creates an especially hazardous condition, to direct the operator to correct the hazardous condition immediately or return to a mooring and to remain there until the situation creating the hazard is corrected or ended. Reasons for using the authority are insufficient personal flotation devices or firefighting equipment aboard and overloading. Other unsafe conditions that may create especially hazardous conditions will be defined in future regulations. Failure to comply with the orders of the Boarding Officer subject the offender to penalties provided for under the law.

Additionally the law authorizes any Coast Guard District Commander (not his staff) to issue regulations for a specific boat designating that boat unsafe for a specific voyage on a specific body of water when he has determined that such a voyage would be a manifestly unsafe voyage.

CHAPTER 5

Rules of the Road

Introduction

Men have been sailing the seas since the beginning of history. For thousands of years, the open ocean was a lonely place to be. Vessels rarely met on the high seas and the sight of an occasional sail on the horizon was an event guaranteed to break the monotony of the long voyage. As the world's trade increased and traffic became more regular on established shipping lanes, the chances of vessels meeting became greater. In 1863, Great Britain and France adopted a code of uniform regulations for preventing collisions at sea. In 1864, the Congress of the United States adopted a similiar set of rules. In 1865, other countries adopted these rules but it was not until 1889 that representatives from the world's seafaring nations met in Washington D. C. to create an international code of rules for vessels on the high seas. The language barrier must have been formidable since these men were attempting to define exact shades of meaning. Since maritime customs of that day differed widely, it is to their everlasting credit that they managed to agree on a code of rules for vessels at sea. This code was known as the International Rules of the Road and was in use until the International Rules of 1948 were adopted and put into effect. There have been revisions since then but, by and large, the changes have been comparatively minor.

It is important to point out that the above mentioned rules apply to the international waters of the high seas only. Territorial waters were left to the jurisdiction of each country involved. The United States has legislated in this area, although no single code could be expected to cover all regions and special situations in U. S. waters. Consequently, we have several codes. These codes are commonly known as the Inland Rules, the Great Lakes Rules and the Western Rivers Rules. Each code applies to certain waters and each contains rules for special situations peculiar to these waters. In addition to these, we also have Pilot Rules, the Department of the Army Rules and Regulations, the Act of April 25, 1940, better known as the Motorboat Act, and others.

Enough rules to sink a ship? Not really. The primary purpose of each and every one of them is to prevent collisions at sea and on our navigable waters. There are almost as many rules as there are possible situations but, strangely enough, they work! When the early draftsmen of these rules gave sailing craft the right-of-way over power driven vessels, they did so for a very good reason. Sailing vessels do not enjoy the relative ease of maneuverability of powered craft since they depend on the wind for their propulsion. When our Inland Rules were written (in 1897), they were patterned closely on the International (high seas) Rules and that feature giving sailing vessels the right-of-way (most of the time) over powered vessels was retained. The writers of our early Inland Rules can be forgiven for not having the foresight to envision a confrontation between an 8 foot long sail boat and a 1,000 foot long ocean liner. Until a few years ago, your teen-aged daughter, out for a day's sail in a sailing dinghy, could force the RMS Queen Mary to give way in the congested waters of New York harbor. This is not so today but one cannot blame the "Mary" for finally giving up in sheer desperation and consenting to spend her declining years in the sedate comfort of the Port of Long Beach, California.

For the student who is about to tackle the subject of Rules of the Road for the very first time - a word of encouragement. You will not be expected to know them all. However, regardless of where you

do your boating, other skippers have the right to assume that you know what you're doing. So the Rules that you will have to learn are those which apply to *your boat* and the waters on which you will sail or cruise. Remember, when you take the wheel or tiller, there is a *presumption of knowledge!* If you fail to observe the rules, the fact that you did not know them will not be accepted as a valid defense in any citation which may result as a consequence of your actions.

Jurisdiction

All vessels are required to observe the rules of the road which apply to the waters on which they navigate. These codes, mentioned briefly heretofore, are to be found in the following U. S. Coast Guard publications and apply to the waters described below:

Rules of the Road, International—Inland (CG-169)

The Coast Guard has included the Rules for both these waters in the one publication, CG-169.

International Rules apply on the high seas seaward of the established boundary lines between International and Inland waters, and on certain foreign waters. Inland Rules apply to all waters inshore of these boundary lines except the Great Lakes and the Western Rivers. The boundary lines for Inland Rules of the Road are established by the Commandant of the Coast Guard. A boundary line is designated for most bays, sounds, harbors, rivers or estuaries in U. S. waters which connect to the high seas. These lines are described in the back of CG-169 and CG-184 and, where appropriate, on various charts of coastal waters.

Rules of the Road, Great Lakes (CG-172)

Great Lakes rules apply to the waters of the Great Lakes and their connecting tributaries as far east as Montreal.

Rules of the Road, Western Rivers (CG-184)

Western Rivers rules apply to the waters of the Mississippi River between its source and the Huey P. Long Bridge and all of its tributaries emptying thereinto and their tributaries, that part of the Atchafalaya River above its junction with the Plaquemine-Morgan City alternate waterway, and the Red River of the North.

Some Definitions

As we develop the subject, we will be using terms which may be unfamiliar or new. Because these rules are in fact *laws*, exact definitions become very important. The following terms will appear throughout this Chapter, so let's "define our terms" before we proceed further.

Vessel—Every description of watercraft used or capable of being used as a means of transportation on the water.

Power Vessel—Any vessel propelled by machinery, including any sailing vessel under sail AND power.

Steam Vessel—Any vessel propelled by machinery.

Sailing Vessel—Any vessel which is under sail alone, including any power vessel under sail and not under power.

Underway—Not at anchor, aground, or made fast to the shore.

Danger Zone—The area from dead ahead of a vessel to two points abaft her starboard beam.

Right-of-Way—The right and duty to maintain Course and Speed.

Privileged Vessel—The vessel which has the right-of-way.

Burdened Vessel—The vessel which must keep clear of the privileged vessel.

Visible (when applied to lights)—Visible on a dark, clear night.

Short Blast (on whistle)—A blast of about one second's duration.

Prolonged Blast (on whistle)—A blast of from four to six seconds' duration.

Distinct Blast (on whistle)—A clearly audible blast of any length.

Engaged In Fishing—Fishing with nets, lines or trawls, but does not include fishing with trolling lines.

Point—An arc of 11¼° of the horizon (32 points equal the full circle 360°).

General Categories

As we study the Rules of the Road, we will divide them into three general categories; (1) Lights and Shapes; (2) Steering and Sailing Rules, and Sound Signals; and (3) Fog Signals. The latter two will be separated into four sections, one for each set of Rules. The first category, Lights and Shapes, will be separated into two sections, one for the "Motorboat Act" waters and the other for international waters of the high seas.

Lights and Shapes

Your lights convey information to others under conditions of restricted visibility or at night when your vessel is not otherwise visible. The lights that you must carry and display depend on whether your vessel is under power or under sail, its length and the waters on which you do your boating. The regulations for lights for boats navigating on all Inland waters, the Great Lakes and the Western Rivers, fall under the jurisdiction of the Motorboat

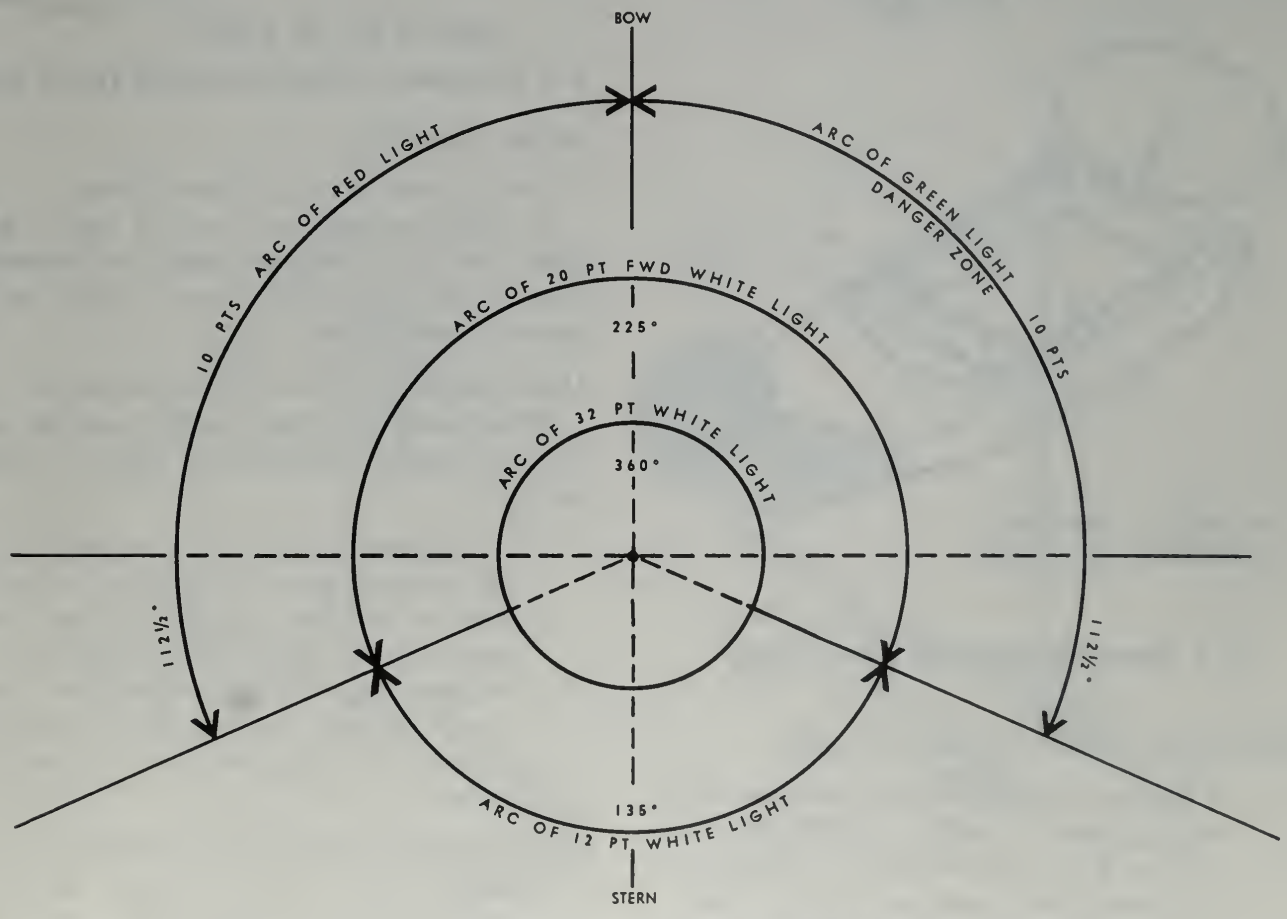
Act for vessels not over 65 feet in length. If you do your boating on international waters, the International Rules apply. Lights prescribed under the International Rules may be carried and displayed on all inland waters, including the Great Lakes and the Western Rivers but not the reverse. So, if your boating is done sometimes on inland and sometimes on international waters, you should equip your craft with international lights.

It might be well to mention at this point that a motorboat (under the Motorboat Act) is any vessel not over 65 feet in length that is propelled by machinery. A sailing auxiliary (a sailboat which has an engine installed or which has an outboard engine aboard which can be mounted and used for propulsion) is considered to be a motorboat within the meaning of the Motorboat Act and must display the lights of a motorboat of its class while underway under power, reglardless of whether the vessel is under sail and power or under power only.

Arc of Visibility of Lights on Vessels

Lights carried on vessels are defensive in the sense that they are not intended for illumination but for identification or warning. The law requires that these lights be clearly visible throughout their prescribed arc of visibility and that they be effectively screened so that they will not be visible through the balance of the circle. The arc of visibility for lights on vessels is called out in points, each point being equal to 11¼ ° of the circle. Thirty-two points equal a complete circle. The arc of visibility for prescribed lights on vessels are as follows:

10 points	(112½ °)	Visible from right (dead) ahead to 2 points abaft the respective beams.
12 points	(135°)	Visible from right (dead) astern to 2 points abaft the beam on both sides.
20 points	(225°)	Visible from right (dead) ahead to 2 points abaft the beam on both sides.
32 points	(360°)	Visible throughout the complete circle of the horizon.



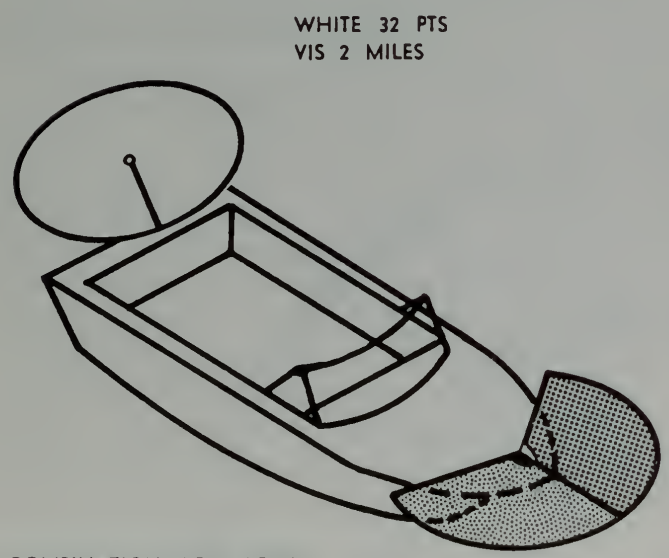
5-1 Degrees of Visibility of Lights

Lights under the Motorboat Act (Inland, Western Rivers and Great Lakes)

These lights must be carried and exhibited by all motorboats in all weathers from sunset to sunrise when underway. No other lights which can be mistaken for these lights may be displayed.

Motorboats under 26 Feet in Length

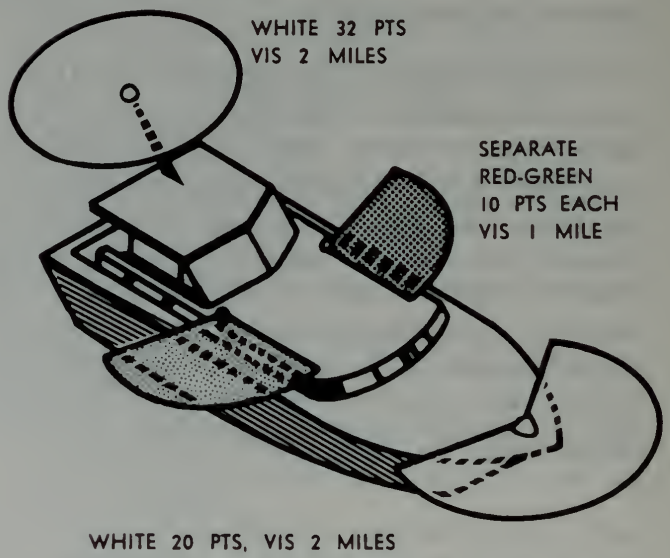
1. A 32-point white light aft, visible for 2 miles, high enough to be seen all around the horizon. This light may be carried off the center line if necessary.
2. A combined lantern in the forepart of the vessel, lower than the white light aft, showing green to starboard and red to port, of 10 points each, fixed so as to show from right ahead to 2 points abaft the beam on their respective sides, visible for 1 mile.



5-2 Motorboat Under 26 Feet in Length

Motorboats 26 Feet to 65 Feet in Length

1. A 20-point white light in the fore part of the vessel as near the stem as practicable, fixed to show from right ahead to 2 points abaft the beam on both sides, visible for 2 miles.
2. A 32-point white light aft to show all around the horizon, visible for 2 miles. This light must be higher than the white light forward.
3. Separate red and green side lights, red to port and green to starboard, of 10 points each, fixed to show from right ahead to 2 points abaft the beam on their respective sides, visible for 1 mile.



5-3 Motorboat 26 Feet through 65 Feet in Length

Sailing Auxiliaries

Under Sail and Power, or Power Alone

A sailing auxiliary not over 65 feet in length must carry and exhibit the same lights as a motorboat of its class while underway under sail and power or power alone.

Under Sail Alone, Under 26 Feet in Length

When under sail alone, a sailing auxiliary under 26 feet in length must carry and exhibit the following lights:

1. A combined lantern in the forepart of the vessel, showing green to starboard and red to port, of 10 points each, fixed so as to show from right ahead to 2 points abaft the beam on their respective sides, visible for 1 mile. NOTE: Separate 10-point red and green side lights may be carried in lieu of the combined lantern.
2. A 12-point white light aft, visible for 2 miles, fixed so as to show from right astern to 2 points abaft the beam on both sides of the vessel.

NOTE: Under Great Lakes Rules, the 12-point white stern light is not required for a vessel underway under sail alone; but a white light must be available to display on the quarter from which a vessel is approaching. This light must be shown in time to prevent a collision.

Under Sail Alone, 26 Feet Through 65 Feet in Length

When under sail alone, a sailing auxiliary 26 feet in length through 65 feet in length must carry and exhibit the following lights:

1. Separate red and green side lights showing red to port and green to starboard, of 10 points each, fixed to show from right ahead to 2 points abaft the beam on their respective sides, visible for 1 mile.

2. A 12-point white light aft, visible for 2 miles, fixed so as to show from right astern to 2 points abaft the beam on both sides of the vessel.

NOTE: Under Great Lakes Rules, the 12-point white stern light is not required for a vessel underway under sail alone; but a white light must be available to display on the quarter from which a vessel is appproaching. This light must be shown in time to prevent a collision.

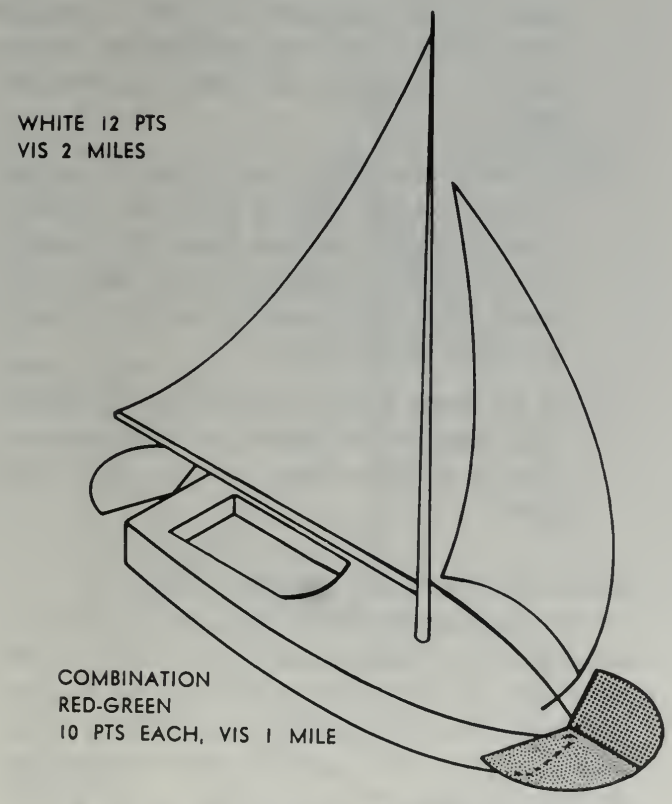
Sailboats

Sailboats (sailing vessels with no engines aboard) must carry and exhibit the following lights:

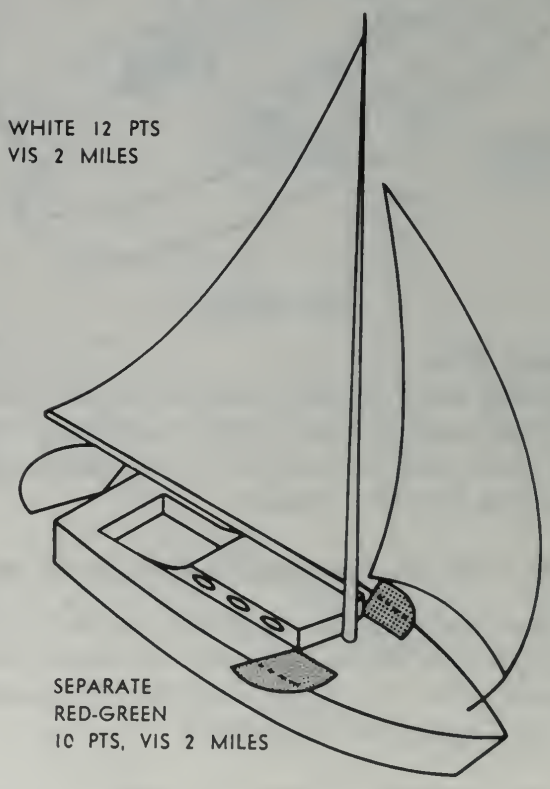
1. Separate red and green side lights, showing red to port and green to starboard, of 10 points each, fixed to show from right ahead to 2 points abaft the beam on their respective sides, visible for 2 miles.

2. A 12-point white light aft, visible for 2 miles, fixed so as to show from right astern to 2 points abaft the beam on both sides of the vessel.

NOTE: Under Great Lakes Rules, the 12-

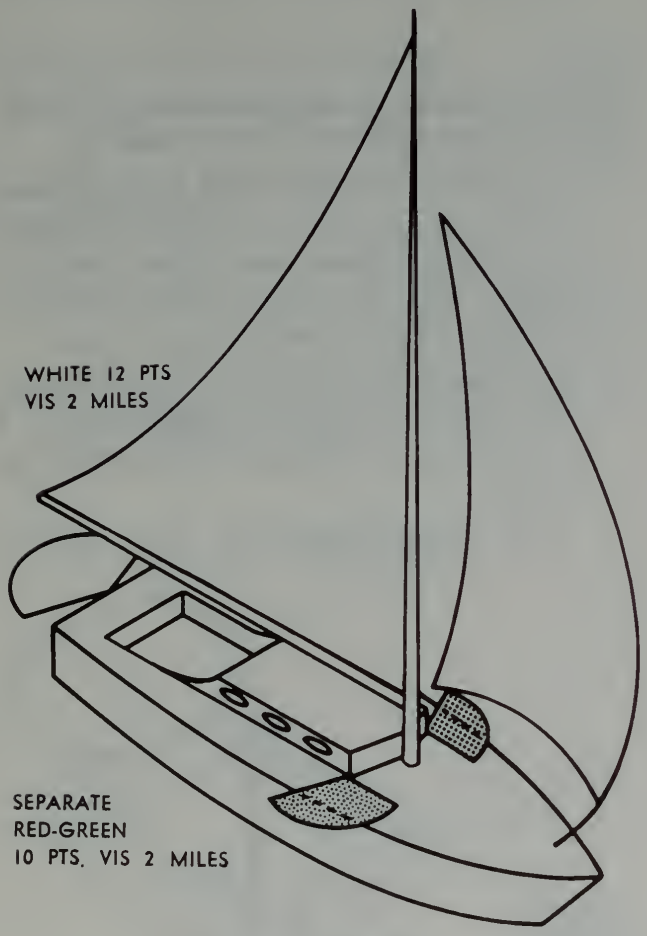


5-4 Sailing Auxiliary, Under Sail Alone, Under 26 Feet in Length



5-5 Sailing Auxiliary, Under Sail Only, 26 Ft. to 65 Ft. in Length

point white stern light is not required for a vessel underway under sail alone; but a white light must be available to display on the quarter from which a vessel is approaching. This light must be shown in time to prevent a collision.



5-6 Sailboat

Rowing Boats

Rowing boats, whether under sail or under oars, shall have ready at hand a lantern showing a white light which shall be temporarily exhibited in sufficient time to avert a collision.

Lights under the International Rules of the Road

These lights must be carried and exhibited by all vessels in all weathers from sunset to sunrise when underway. No other lights which can be mistaken for these lights may be displayed.

Motorboats under 40 Feet in Length

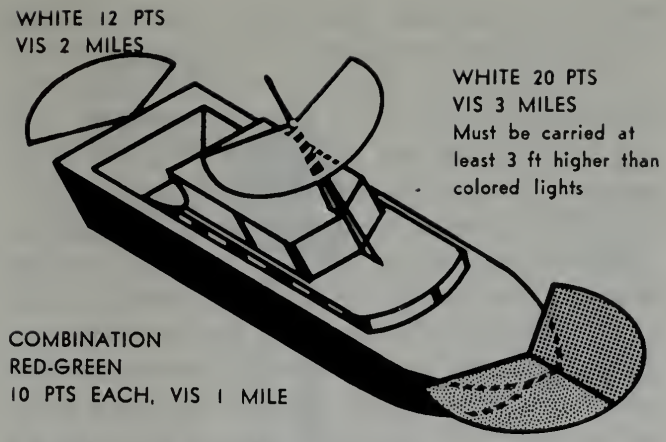
1. A combined lantern in the forepart of the vessel, showing green to starboard and red to port, of 10 points each, fixed so as to show from right ahead to 2 points abaft the beam on their respective sides, visible for 1 mile. Or separate red and green side lights, red to port and green to starboard, of 10 points each, fixed to show from right ahead to 2 points abaft the beam on their respective sides, visible for 1 mile.
2. In the forepart of the vessel, where it can best be seen, a white light of 20 points, visible 3 miles, fixed so as to show from right ahead to 2 points abaft the beam on both sides of the vessel. This light must be carried at least 3 feet higher than the colored lights.
3. At the stern, a white 12-point light, visible 2 miles, fixed so as to show from right astern to 2 points abaft the beam on both sides of the vessel.

Motorboats 40 Feet Through 65 Feet in Length

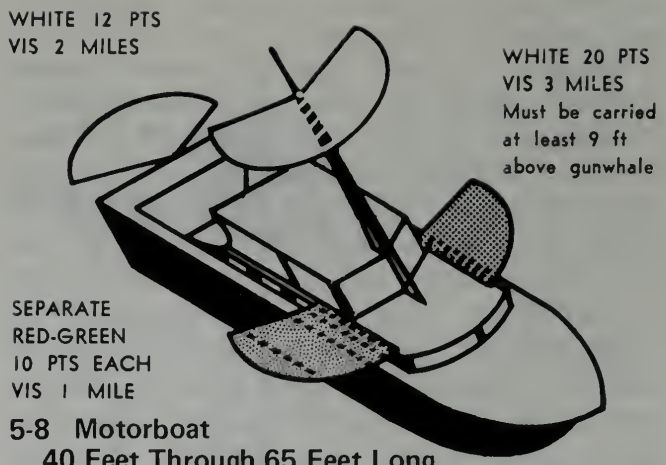
1. Separate red and green side lights, red to port and green to starboard, of 10 points each, fixed so as to show from right ahead to 2 points abaft the beam on their respective sides, visible 1 mile. A combination lantern may be substituted for these separate side lights.
2. In the forepart of the vessel, where it can best be seen, a white light of 20 points, visible 3 miles, fixed so as to show from right ahead to 2 points abaft the beam on both sides of the vessel. This light must be carried at least 9 feet above the gunwale.
3. At the stern, a white 12-point light, visible 2 miles, fixed so as to show from right astern to 2 points abaft the beam on both sides of the vessel.

Under Sail and Power, or Power Alone

A sailing auxiliary must carry and exhibit the same lights as a motorboat of its class while underway under sail and power or power alone. In practice, the 20-point white light, required to be placed in the forepart of the vessel, is generally fixed on the foremast high enough so that it will not be obscured by the jib.



5-7 Motorboat to 40 Feet Long



5-8 Motorboat 40 Feet Through 65 Feet Long

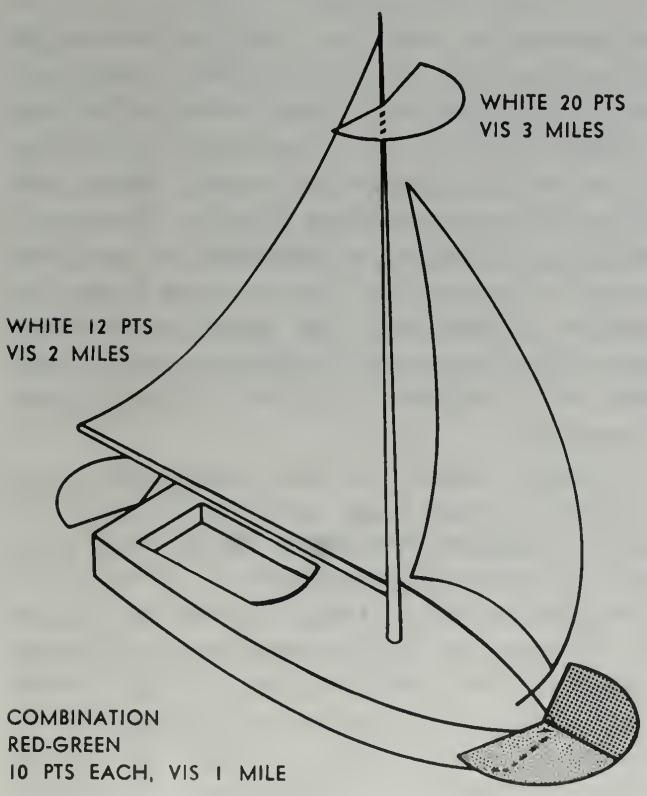
Under Sail Alone

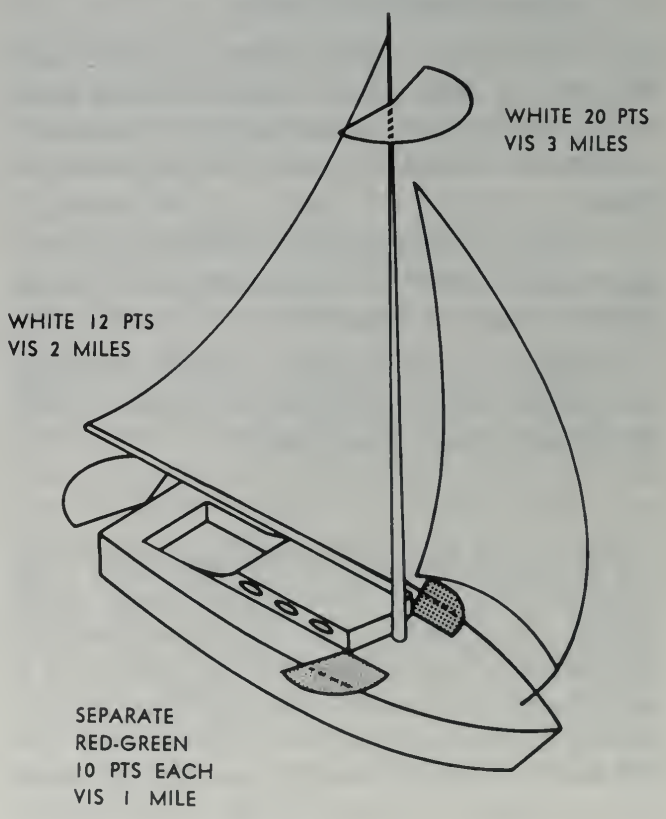
A sailing auxiliary underway under sail alone must carry and exhibit the same lights as a motorboat of its class except the 20-point white light, which is extinguished. A sailing auxiliary *under sail alone* may display at the top of the foremast two lights in a vertical line (one over the other) sufficiently separated so as to be clearly distinguished. The upper light shall be red and the lower light shall be green. Both lights shall be 20-point lights, visible 2 miles, fixed so as to show from right ahead to 2 points abaft the beam on both sides of the vessel. These lights are optional for sailboats and sailing auxiliaries under sail only.

Sailboats

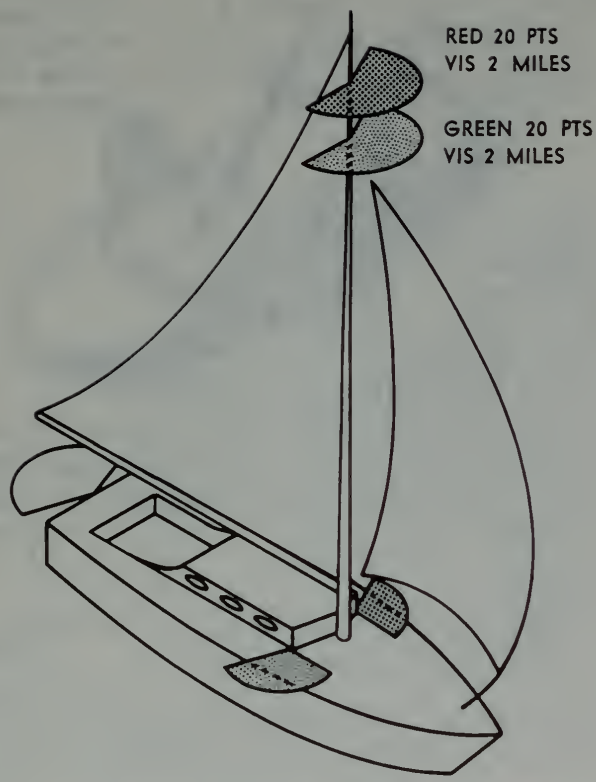
Sailing vessels with no engines aboard shall carry and exhibit the following lights:

1. Separate red and green side lights, showing red to port and green to starboard, of 10 points each,

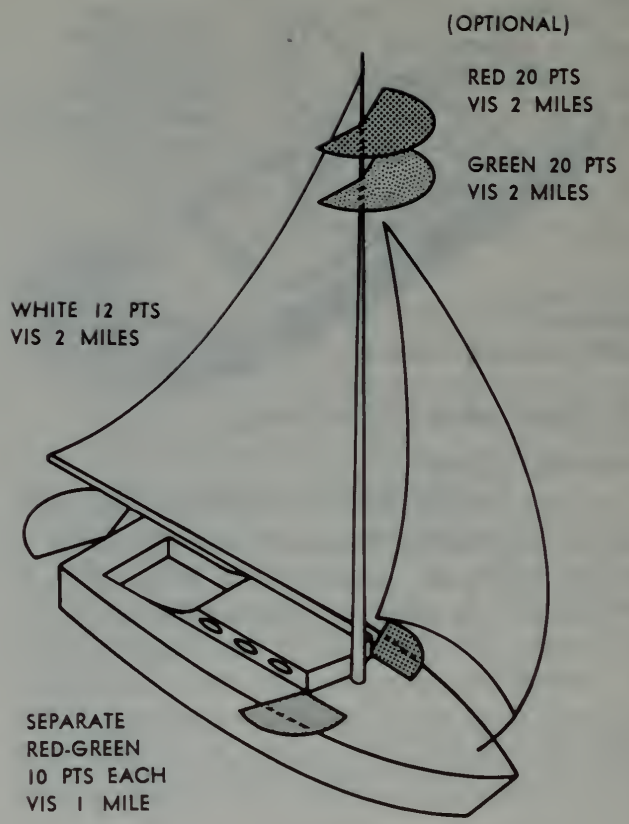




5-9 Auxiliaries Under Sail and Power



5-10 Optional for All Boats Under Sail Alone in International Waters Only



5-11 Sailboat 40 Feet or Over

fixed to show from right ahead to 2 points abaft the beam on their respective sides, visible 1 mile. NOTE: Sailing vessels of less than 40 feet may use a combination lantern in place of the separate sidelights.

2. A 12-point white light aft, visible for 2 miles, fixed so as to show from right astern to 2 points abaft the beam on both sides of the vessel.

3. Sailboats may optionally carry the masthead red and green lights described above under SAILING AUXILIARIES UNDER SAIL ALONE.

Large vessels carry lights which should be of some interest to the small boat skipper. Large vessels develop strong wave patterns which the small boat skipper will do well to keep clear of, particularly at night. Large vessels underway at night may be identified by their range lights. Power driven vessels over 150 feet in length underway in international waters carry a 20-point white light, visible 5 miles, in the forepart of the vessel and, abaft this white light and in line with and over the keel, another 20 point white light, also visible 5 miles, and at least 15 feet higher than the forward white light. When a large vessel is approaching at night, these range lights will be seen one above the other. The vessel's heading with relation to your boat can be determined by the position of these range lights. For instance, if these range lights appear exactly above one another, the vessel is heading straight for your boat and it's important to get out of its way as soon as possible!

In inland waters, the after range light is optional for seagoing steam vessels. On steam vessels, an after range light must be shown. This range light is a white, 32-point light.

Ferryboats plying Inland waters are usually double-ended and have a specific set of lighting requirements. Two sets of colored side lights are carried and one set is used according to which direction the ferry is moving. The white lights are seen all around the horizon (32 points) and, in addition,

they may carry a special light assigned to it by the officer in charge of Marine Inspection. This special light may be of any color and will usually be carried amidships, at least 15 feet above the range lights, visible all around the horizon.

Tow boats and the barges they push or tow are lighted according to each set of rules in a different manner. Our rivers and our harbors are constantly being dredged. Dredges have equipment protruding from them and pipelines or barges which carry away the waste. These units are lighted to warn you to keep clear at night. Buoy tenders and vessels working over wrecks also have their own set of lighting requirements. Certain prescribed areas have special lighting combinations which are peculiar to the area. For instance, on the Gulf Intracoastal Waterway the rules governing towed vessels in Western Rivers are followed. Another set of rules governs the waters around New York harbor and the Hudson River. Specific lighting requirements are prescribed for vessels which are on pilot duty, either on station or on their way to station. The lights which will be seen on vessels which denote their occupation will usually be vertically arranged and will be white or red or a combination of these colors. It is important to realize that whenever you see a lighting arrangement other than the regular running lights on vessels in your area, the vessels thus lighted are unable to maneuver except with difficulty. In some cases, they cannot maneuver at all. It is always a good idea to approach these vessels cautiously and keep well clear of any equipment which might be projecting from them. The student is advised that lighting patterns on various working vessels vary greatly and would require a considerable mental effort to memorize. Rather than attempt to do this, play it safe and give them a wide berth.

Anchor Lights

Certain anchorage areas have been designated by the Secretary of the Army as "special anchorage areas" and vessels not over 65 feet in length may anchor in these areas without being required to show an anchor light at night. Under all other conditions, all vessels must display one or more lights while at anchor at night. All four sets of rules require a vessel under 150 feet in length to display a white 32-point light, carried forward, where it can best be seen. In International, Inland, and Western Rivers, this light must be visible for 2 miles. On the Great Lakes, the visibility requirement for this anchor light is 1 mile. Large vessels over 150 feet in length are required by International, Inland and Western Rivers Rules to carry two anchor lights, the forward light being carried higher than the after light. On the Great Lakes, the anchor lights are carried in pairs, two forward at the same height, arranged so that one or the other, or both, are visible all around the horizon, and two aft, similarly arranged but lower than the forward lights. In addition, Great Lakes Rules require vessels over 150 feet in length to display white deck lights at 100 ft. intervals along the deck, visible from any angle of approach.

Shapes (Day Signals)

In the daytime, vessels engaged in certain specific occupations are required to display signals or shapes. The list of these signals is long and there would be no point in attempting to memorize them. Shapes are usually fabric-covered frames in the shape of balls, cones, diamonds or cylinders. Day signals and shapes are used to indicate vessels which are given special privileges by the Rules of the Road (such as vessels engaged in fishing—Rule 26). If a vessel is entitled to a privilege, it must display the proper shape to obtain it. A good rule-of-thumb would be to consider all vessels which display such shapes as being incapable of maneuvering except with difficulty, and thus unable to react quickly to situations imposed upon them by other vessels. There is one situation, however, where this rule-of-thumb does not apply. Rule 14 of the International Rules requires a sailboat underway under sail and power to display by day a black conical shape, point downwards, carried forward where it can best be seen. This exception to the rule-of-thumb is not serious since the signal just described will seldom, if ever, be encountered. Thus for all practical purposes the rule-of-thumb remains inviolate. Whenever you see a vessel at anchor or underway displaying a day signal, approach it with caution or stay away from it if possible.

These rules determine which vessel has the right-of-way in situations where vessels are meeting, crossing or overtaking. In each case (except for vessels meeting bow-on or nearly so) one vessel is "privileged" and has the right-of-way and the other is "burdened" and must keep clear of the privileged vessel.

Privileged Vessel Duty

The vessel which has the right-of-way (the privileged vessel) has a duty to maintain course and speed. This is logical in the sense that it gives the burdened vessel an opportunity to base its actions on a known set of conditions. The privileged vessel's duty to maintain course and speed ends abruptly the instant a collision is imminent. The general prudential rule, mentioned later in this chapter, will explain this but for the moment it is important to realize that the privileged vessel also becomes burdened when a collision is imminent and the situation is considered to be "in extremis."

Burdened Vessel Duty

The vessel which does not have the right-of-way (the burdened vessel) has a duty to take positive and timely action to keep out of the way of the privileged vessel. *This does not mean to increase speed and cross ahead of the privileged vessel!* In fact, the rules state that the burdened vessel shall, if possible, avoid crossing ahead of the privileged vessel. The burdened vessel, when changing heading to comply with the Rules of the Road, should make such changes in heading smartly and definitely in order that its action can be easily observed by those aboard the privileged vessel. The burdened vessel usually conforms to the rules in crossing situations by changing course briefly or slowing down (or both) and passing astern of the privileged vessel. However, before we get into this, let's take a good look at a very important rule.

The General Prudential Rule

The General Prudential Rule is found in all four sets of Rules of the Road. It is called Article 27 in the Inland Rules. It is called Rule 27 in the International Rules and also in the Great Lakes Rules. It is called "Rule Numbered 25" in the Western Rivers Rules. In each case, however, its wording (and meaning) is almost the same.

> 'In obeying and construing these rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances, which may render a departure from the above rules necessary in order to avoid immediate danger. . . ."

Thus we see that the General Prudential Rule does not apply only on such occasions as it may appear convenient. The steering and sailing rules must be observed under all normal circumstances. It is only when a collision is imminent, and would certainly occur if both vessels continued on their present course and speed, that the General Prudential Rule applies. The Courts have held . . .

> ". . . When such departure becomes necessary, neither vessel shall have the right-of-way and both vessels shall navigate with caution until the danger of collision is over."

As we have seen, the privileged vessel is obliged to maintain course and speed under normal conditions until such time that a collision becomes imminent. At that instant, the privileged vessel also becomes burdened and is obliged to take all actions necessary to avoid the collision. To put it simply, the privileged vessel does not, at any time, have the right-of-way *through the hull* of another vessel!

When Rules of the Road Apply

It has been said (in jest) that risk of collision exists whenever two vessels are on the same ocean at the same time. While we know this to be a gross exaggeration, the exact time when steering and sailing rules must be applied is difficult to define. Mr. Justice Clifford, in N.Y. & LIVERPOOL vs RUMBALL, said, "Rules of navigation are obligatory on vessels approaching each other, from the time the necessity of precaution begins, and continue to be applicable as the vessels advance, so long as the means and opportunity to avoid danger remain. They are equally inapplicable to vessels of any description while they are yet so distant from each other that measures of precaution have not become necessary to avoid a collision."

From this, it is comparatively simple to define

the time when steering and sailing rules of the road *do not* apply. They do not apply when the vessels are so far apart that a danger of collision will not arise *regardless of the actions of either vessel.* Thus, by elimination, we can safely deduce that if the vessels are sufficiently close to each other that a departure from the rules by either vessel will create a danger of collision, steering and sailing rules must be applied from that point in time until both vessels are again clear of each other.

We should keep in mind that compliance with the rules is *mandatory* upon each vessel, and not optional. There is no choice of action by either vessel until the danger of collision is so imminent that *both* vessels must take evasive action.

The Situations

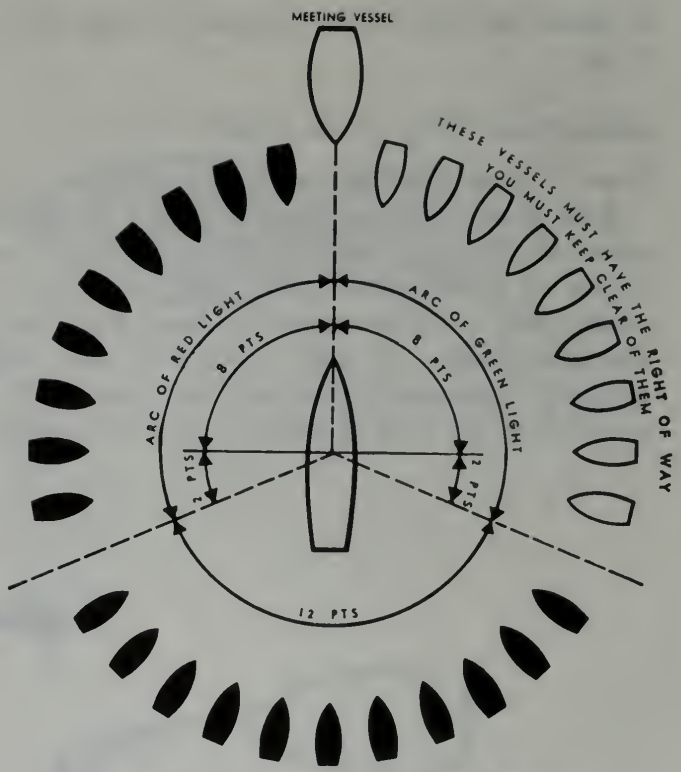
Steering rules between power vessels are based on all possible situations. In each case, both vessels must observe the rules until they are well clear of one another. Basically, there are three main situations which can lead to a collision afloat. These situations are:

The meeting situation
The crossing situation
The overtaking situation

All of the situations between power vessels are shown in the diagram on this page. Remember, rules apply when two or more vessels are in sight of one another and only when the vessels are sufficiently close that for both vessels to continue on their present course and speed would create a danger of collision.

You are the skipper of the vessel in the center of the diagram. You must keep out of the way of any vessel approaching you in the arc from dead ahead (or right ahead) of you to 2 points abaft your starboard beam. All the other vessels in the diagram — except the meeting vessel — must keep clear of you. Both you and the meeting vessel must alter course as necessary to pass clear of each other.

Normally, all the situations can be observed in the making by simply taking a series of bearings on the other vessel or its lights at night. Unless the vessels are sailing on courses which parallel one another, if the bearings do not change substantially between sights, a collision is almost inevitable. The



5-12 Right of Way in a Crossing Situation

"burdened" vessel is required to change course or speed, or both, while the "privileged" vessel is required to hold her course and speed. Where small craft are concerned, good sense is one of the best rules. In other words, when you can, seek to avoid a situation instead of frantically searching your mind for the exactly proper rule to get you safely out of it.

Generally speaking, the right-of-way situations between vessels are quite similar in all four sets of Rules. In order that you might more easily learn the rules which apply to your boat and to your waters, the balance of this chapter will be divided into separate subdivisions — International, Inland, Great Lakes and Western Rivers. In addition, we have included a section on sailboat rules for those of you who operate sailboats. Power boat skippers may be interested in this section since it should help to clear up some of the mystery which surrounds the actions of sailboats seen nearby. Your instructor will tell you which set of Rules apply to your waters. These should be learned thoroughly since there usually isn't enough time to "look it up" when two boats are converging at a speed of 15 knots each. The combined speed of approach in this situation is 30 knots, which means that you will have

a minute at most to decide what you are going to do.

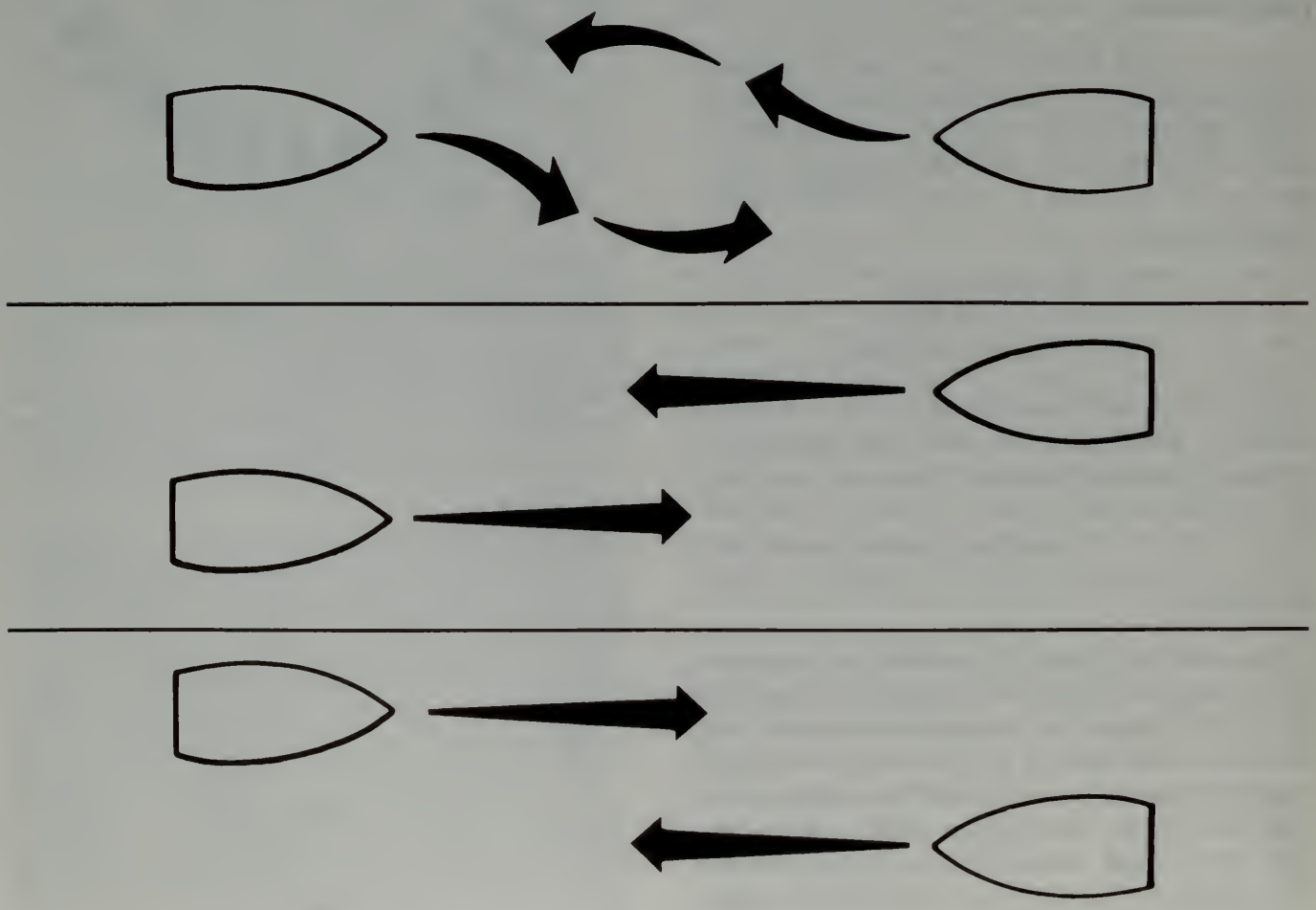
International Rules of the Road

Power Vessels Meeting End on (or Head on)

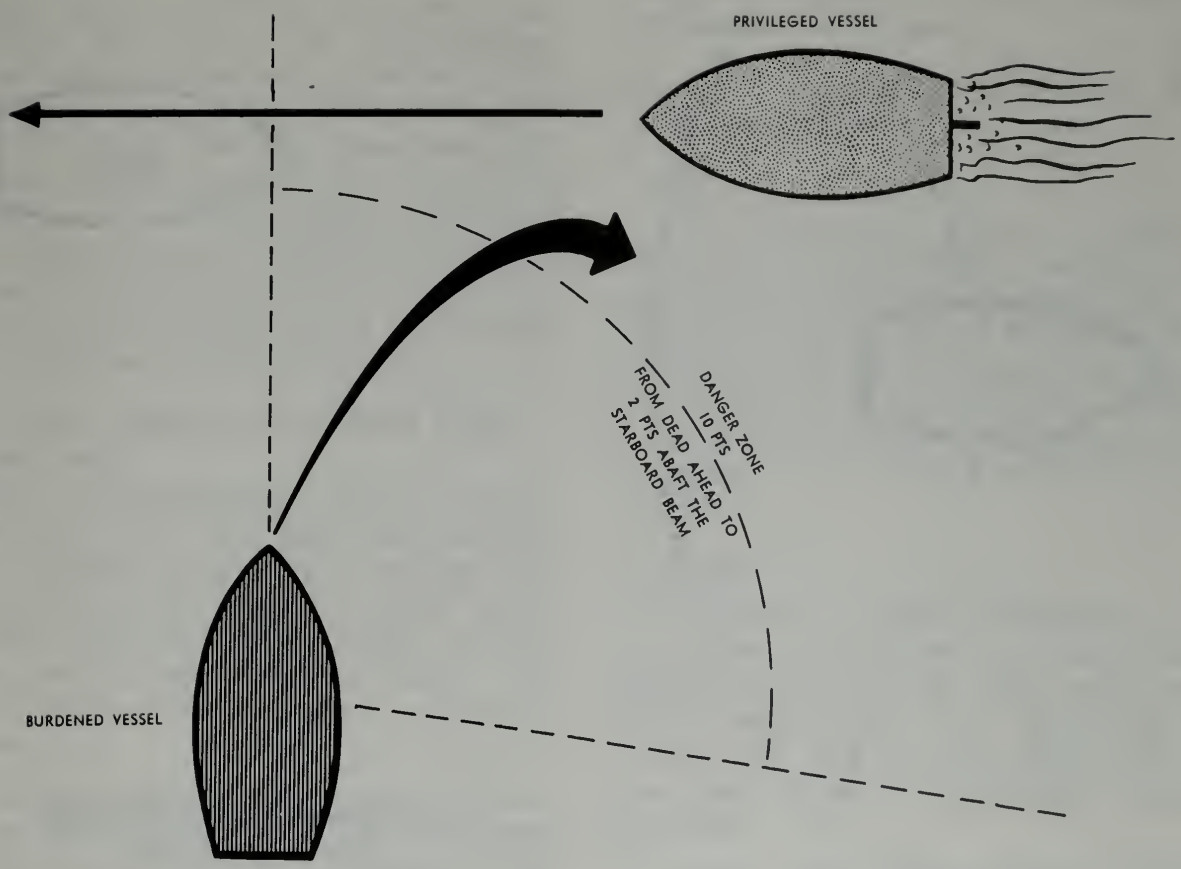
Rule 18 of the International Rules of the Road covers this situation well. When two power driven vessels are meeting head on, or nearly so, so as to involve risk of collision, *neither vessel shall have the right-of-way*, and each vessel shall alter her course to starboard so that each may pass on the port side of the other. Remember, this rule applies only if the vessels are meeting head on in such a way as to involve risk of collision. It does not apply if both vessels, keeping to their respective courses, will pass safely clear of one another.

Power Vessels Crossing

Rule 19 takes care of crossing situations. When two power driven vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other. In the daytime, a vessel approaching on your starboard side can be easily seen. At night, if you see the red side light of another



5-13 Meeting Situations Under International Rules Neither Vessel Has The Right-Of-Way.



5-14 Crossing Situation Under International Rules

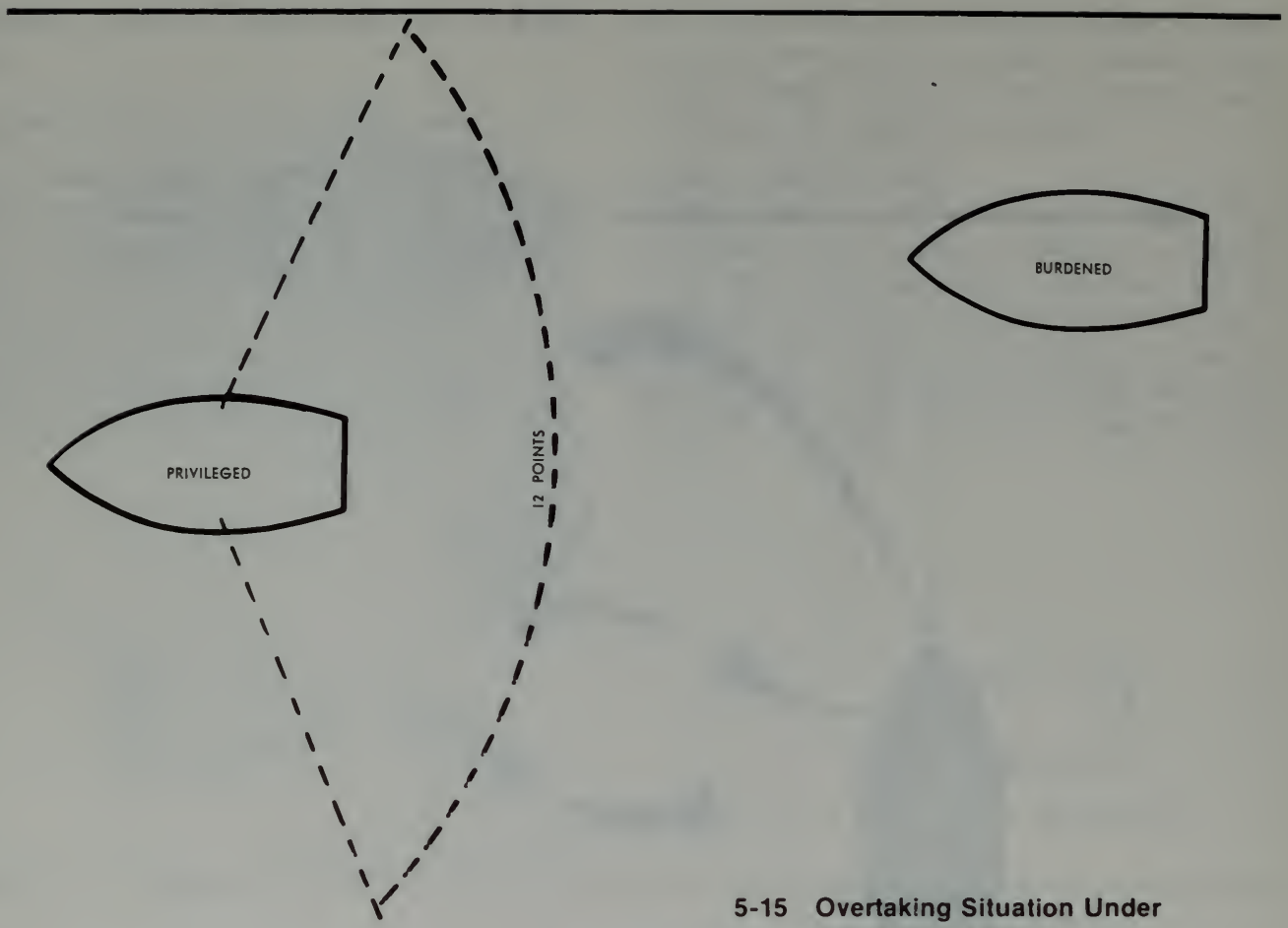
vessel which is crossing your course on your starboard side, that vessel has the right-of-way and you must keep clear.

Power Vessels Overtaking

If a vessel is overtaking another, it is burdened until the overtaken vessel has been passed and is clear. Rule 24 states that every vessel coming up with another vessel from any direction more than 2 points abaft her beam shall be deemed to be an overtaking vessel. No subsequent alteration of the bearing between these two vessels shall relieve the overtaking vessel of her duty of keeping clear of the overtaken vessel until she is finally past and clear. If the overtaking vessel is in doubt whether she is forward or abaft the direction of 2 points abaft the beam of the overtaken vessel, she shall assume that she is an overtaking vessel and shall keep clear. At night, if you are unable to see the overtaken vessel's side lights (red or green), you should assume that you are overtaking and keep clear.

Power Vessels in Narrow Channels and Bends

In a narrow channel, every power vessel shall keep to the right side of the channel when it is safe and practicable to do so. When a power vessel is nearing a bend in a narrow channel where a vessel approaching from the other direction might not be seen, at about the time she arrives within one-half mile of the bend she shall sound one prolonged blast (4 to 6 seconds) on the whistle as a signal. If another vessel is within hearing around the bend, this other vessel shall answer the signal with a similar blast. However, even if no reply is heard to the original signal, the vessel shall navigate the bend with alertness and caution.



5-15 Overtaking Situation Under International Rules

In a narrow channel, a power vessel of less than 65 feet in length shall not hamper the safe passage of a vessel which can navigate only inside such channel. In other words, don't play "right-of-way games" with large vessels in a narrow channel. It is not only against the law but it could be costly. Large deep-draft vessels are difficult to maneuver in narrow channels and must, of necessity, remain within the limits of the channel. Your boat is extremely more maneuverable in the channel and so the rules state that you do not have the right-of-way. This is only common sense.

Right-of-Way of Fishing Vessels

All fishing vessels which are fishing with nets, lines or trawls are considered to be fishing vessels under the International Rules. Vessels fishing with trolling lines are *not* considered to be fishing vessels. Fishing vessels have the right-of-way and all other vessels shall keep out of their way. The student is reminded that the fact that he might be trolling a lure aft of his boat or from outriggers does not make his vessel a fishing vessel under the rules. A fishing vessel must display a basket or two black cones in the rigging. When you see these, it's a good idea to keep well clear.

Sailing Vessel Right-of-Way

When a power-driven vessel and a sailing vessel (under sail only) are proceeding in such directions as to involve risk of collision, the power-driven vessel shall keep clear of the sailing vessel except in the following situations:

1. When a sailing vessel is overtaking a power-driven vessel the overtaken vessel (in this case the power vessel) has the right-of-way, and the sailing vessel shall keep out of the way.
2. A sailing vessel shall keep clear of any vessel engaged in fishing with nets, lines or trawls.
3. In a narrow channel, a sailing vessel shall not hamper the safe passage of a power-driven

vessel which can navigate only inside such channel.

Sailboat skippers should realize, however, that even though power boats are far more maneuverable than sailboats, power boats do not have power brakes. It is foolhardy to defy fate by tacking immediately under the bow of a power boat in the comforting assurance that you have the right-of-way. The power boat's transmission could fail to engage in full reverse and an accident could very likely result. Having the right-of-way is small comfort when viewed in the light of a damaged hull and possible injury to those aboard.

Sound Signals Under the International Rules of the Road

On the international waters or the high seas, one, two and three blast sound signals are considered "course indicating signals" and are accompanied by a change of course or some other action on the part of the vessel sounding such signals. These signals are given only when vessels are in sight of one another. There are three such signals, and they are as follows.

One short blast (1 second) means "I am altering my course to starboard. . . . Two short blasts (1 second each) means "I am altering my course to port. . . . Three short blasts (1 second each) means "My engines are going astern. . . .

Whenever a power vessel which, under the rules, is to keep her course and speed (a privileged vessel), and she is in doubt whether sufficient action is being taken by the other (burdened) vessel to avert a collision, she may indicate such doubt by giving the danger signal. This signal is as follows:

Five or more short blasts (1 second each) on the whistle.

The fact that a vessel sounds the danger signal does not relieve her of her obligations to keep a proper lookout and to observe the general prudential rule.

As stated earlier, sound signals under International Rules are signals indicating an action or doubt and as such are normally not answered by the other vessel. Any whistle signal under the rules may be further indicated by a visual signal consisting of a white light visible all around the horizon (32 points) at a distance of at least five miles, which will operate simultaneously with the whistle and remain lighted and visible during the same period as the sound signal.

Conduct in Restricted Visibility Under the International Rules

Radar

The development of RADAR has made it possible to "see" through fog to a limited degree. The student is cautioned, however, that even though his vessel may be equipped with RADAR, under the International Rules of the Road the information obtained from RADAR does not relieve the vessel so equipped from the obligation of conforming strictly with the rules in conditions of restricted visibility.

Fog Signals

Fog signals are required to be sounded by all vessels (power and sail) in fog, mist, falling snow, heavy rainstorms or any other condition of restricted visibility, whether by day or night. Power-driven vessels shall sound fog signals on the whistle and sailing vessels shall sound fog signals on the fog horn.

A power vessel making headway through the water shall sound one prolonged blast (4 to 6 seconds) on the whistle at least every 2 minutes.

A power vessel underway but stopped and making no way through the water shall sound two prolonged blasts on the whistle, with an interval of about one second between blasts, at least every two minutes.

A sailing vessel underway shall sound, at intervals of not more than one minute, the following signals on the fog horn.

If on the starboard tack — one blast.

If on the port tack — two blasts in succession.

If the wind is abaft the beam — three blasts in succession.

The rules do not specify the length of time for each blast. The "tack" is determined by the relative direction of the wind. Port tack indicates wind is blowing over the port bow. Starboard tack indicates wind is coming over the starboard bow.

Vessels at Anchor

When at anchor, every vessel shall ring the bell rapidly for at least five seconds at intervals of not more than one minute. Large vessels (over 350 feet in length) also sound a gong at the stern when anchored in a fog. All vessels may, in addition, sound three blasts on the whistle or fog horn as follows: One short, one prolonged and one short blast, to give warning of her position and of the possibility of collision to any vessel which appears to be standing into danger of a collision. Towing vessels and fishing vessels sound one prolonged blast followed by two short blasts. Barges or vessels towed sound one prolonged blast and three short blasts (if manned) immediately after the tow's signal.

Speed in Fog

In conditions of impaired visibility, all vessels shall proceed at a moderate speed, having careful regard to the existing circumstances and conditions. A vessel which hears the fog signal of another vessel apparently ahead of her beam shall stop, reverse her engines if necessary, and proceed with caution until danger of collision has passed. In conditions of impaired visibility, speed should be governed to a great extent by the visible distance. It would appear logical to give one-half of the visible distance to the other vessel. Under this assumption, any vessel underway in fog should be able to stop in half of her visible distance. The speed, thus determined would be the *maximum* speed allowed under the rules of good seamanship in the circumstances.

Inland Rules of the Road

Power Vessels Meeting Head-on

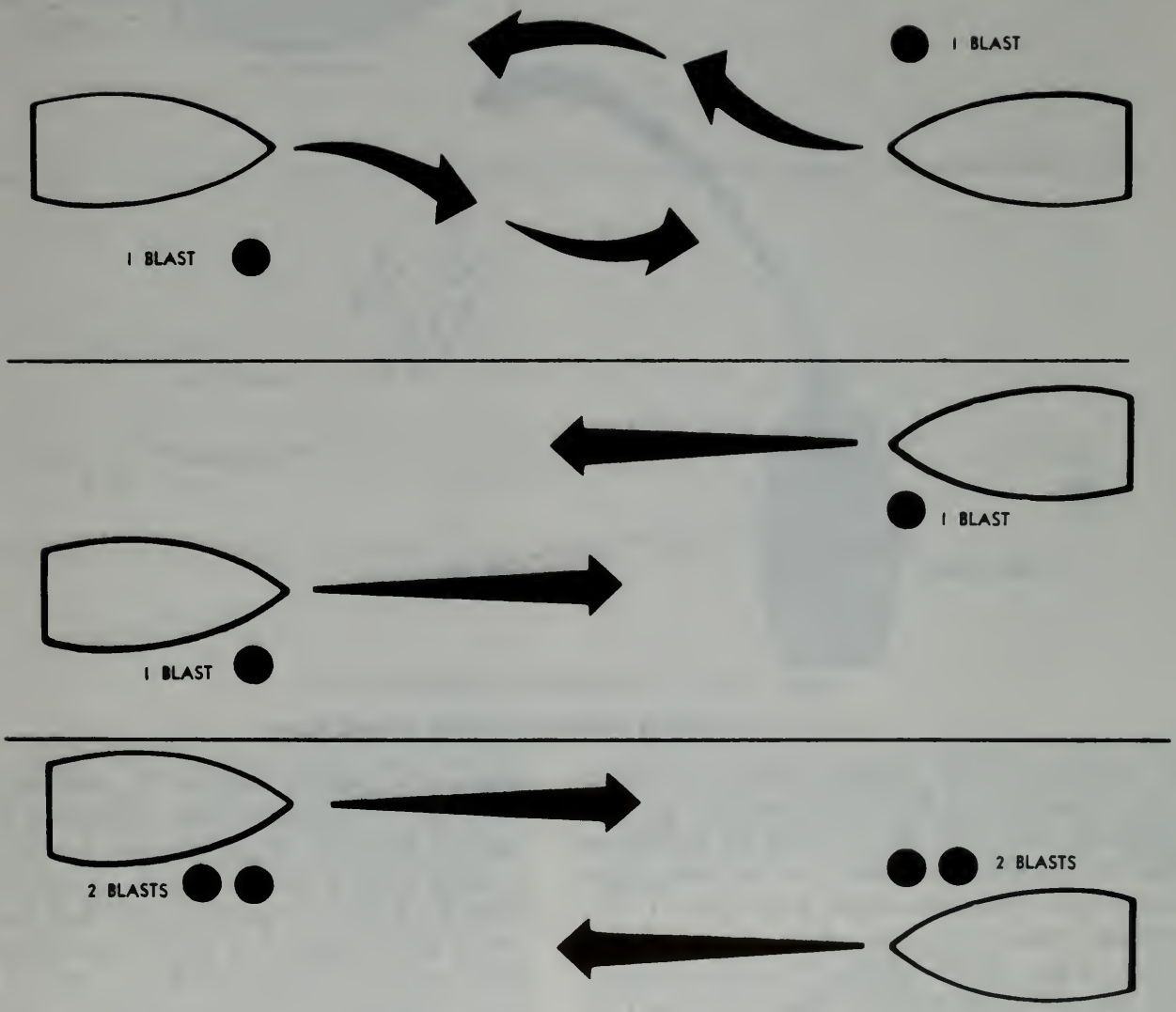
When two power vessels are approaching each other head-on, and a danger of collision arises, neither vessel is privileged and each should alter course to the right to pass clear. One vessel will sound one short (1 second) blast on her whistle, indicating her intention to pass port to port. This signal will be immmediately answered by the other vessel with one short blast. On waters under the Inland Rules of the Road, these whistle signals are signals of intent and assent. As such, each whistle signal shall be answered. The first vessel indicates her intention by a whistle signal and the other vessel answers with a similar signal to indicate that she understands and agrees. Thereupon, both vessels alter their course to starboard smartly and keep the other vessel to port during the passing. If the vessels are meeting, but not on a collision course, and would clear each other with plenty of room to spare without a change of heading, there would be no necessity for either vessel to alter course and they would pass port to port or starboard to starboard simply by exchanging signals. On a starboard-to-starboard passing the signals are two short blasts (1 second each) given by each vessel. In any meeting situation, if either vessel does not understand the other's signals or feels that the type of passage signaled for will be dangerous, she should sound the "Danger Signal," which consists of four or more short blasts (1 second each) on her whistle. When a danger signal is given or heard, both vessels shall stop and continue to exchange signals until they are understood by both vessels before either vessel may proceed again. The cause of most head-on-collisions between vessels is usually carelessness, stubborness or ignorance of the rules.

Power Vessels Crossing

When two power vessels are crossing so as to involve a risk of collision, the vessel which has the other on her starboard side shall keep out of the way of the other. At night, if you see the red light of another vessel which is crossing your course, that vessel has the right-of-way and you must keep clear. In the situation illustrated on page 88, the privileged vessel will sound one short blast (1 second) on her whistle to indicate that she has the right-of-way and will maintain course and speed. The burdened vessel will answer with one short blast on her whistle to indicate that she has heard and understood the signal and will keep clear. If there is any doubt in the mind of the skipper of either vessel concerning the safety of the crossing or the intentions of the other, either vessel will sound the danger signal. When this signal is given or heard, both vessels must stop and exchange signals until the situation is clear to both skippers.

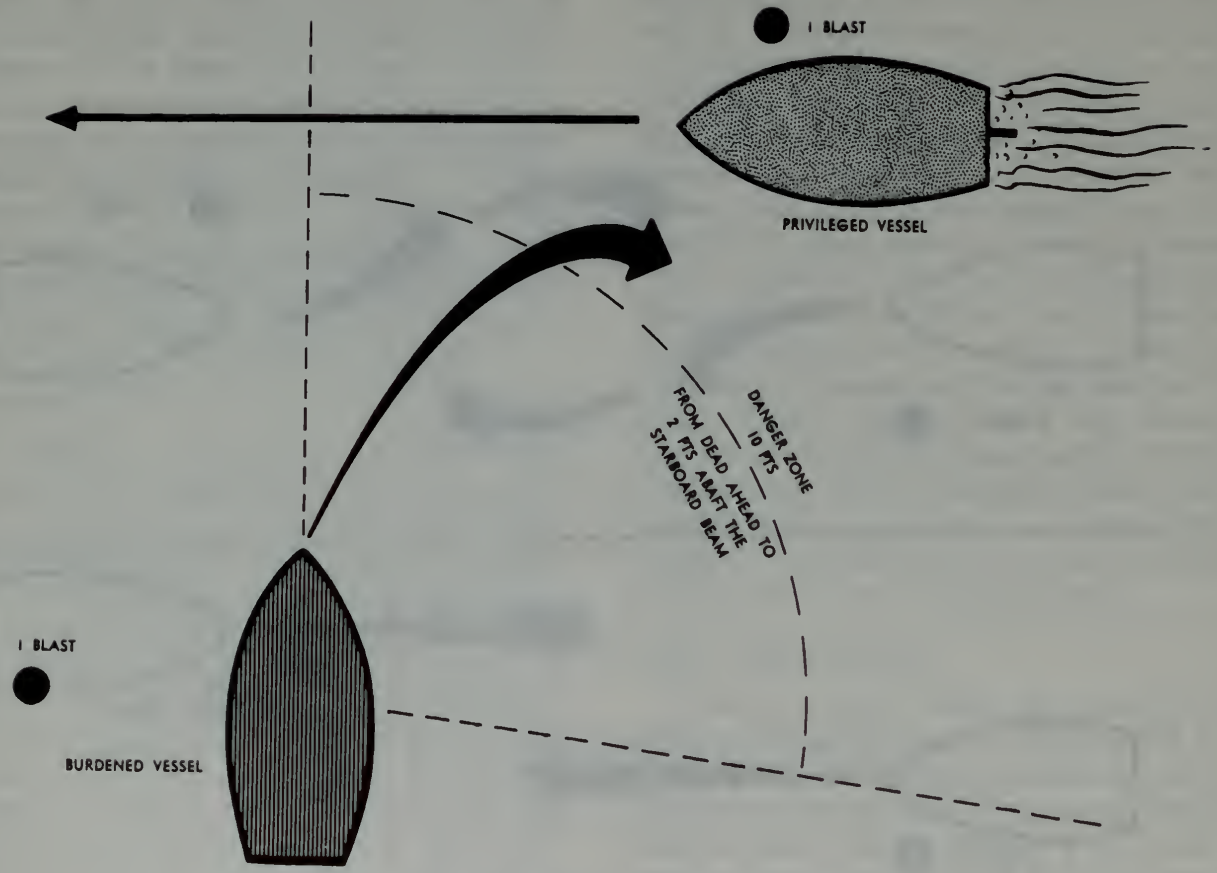
Power Vessels Overtaking

If a vessel is overtaking another, it is burdened until the overtaken vessel has been passed and is clear. Every vessel coming up with another vessel from any direction more than 2 points abaft her beam shall be deemed to be an overtaking vessel.



5-16 Meeting Situations Under Inland Rules

No subsequent alteration of the bearing between these two vessels shall relieve the overtaking vessel of her duty of keeping clear of the overtaken vessel until she is finally past and clear. If the overtaking vessel is in doubt whether she is abaft the direction of 2 points abaft the beam of the overtaken vessel, she shall assume that she is an overtaking vessel and shall keep clear. At night, if you

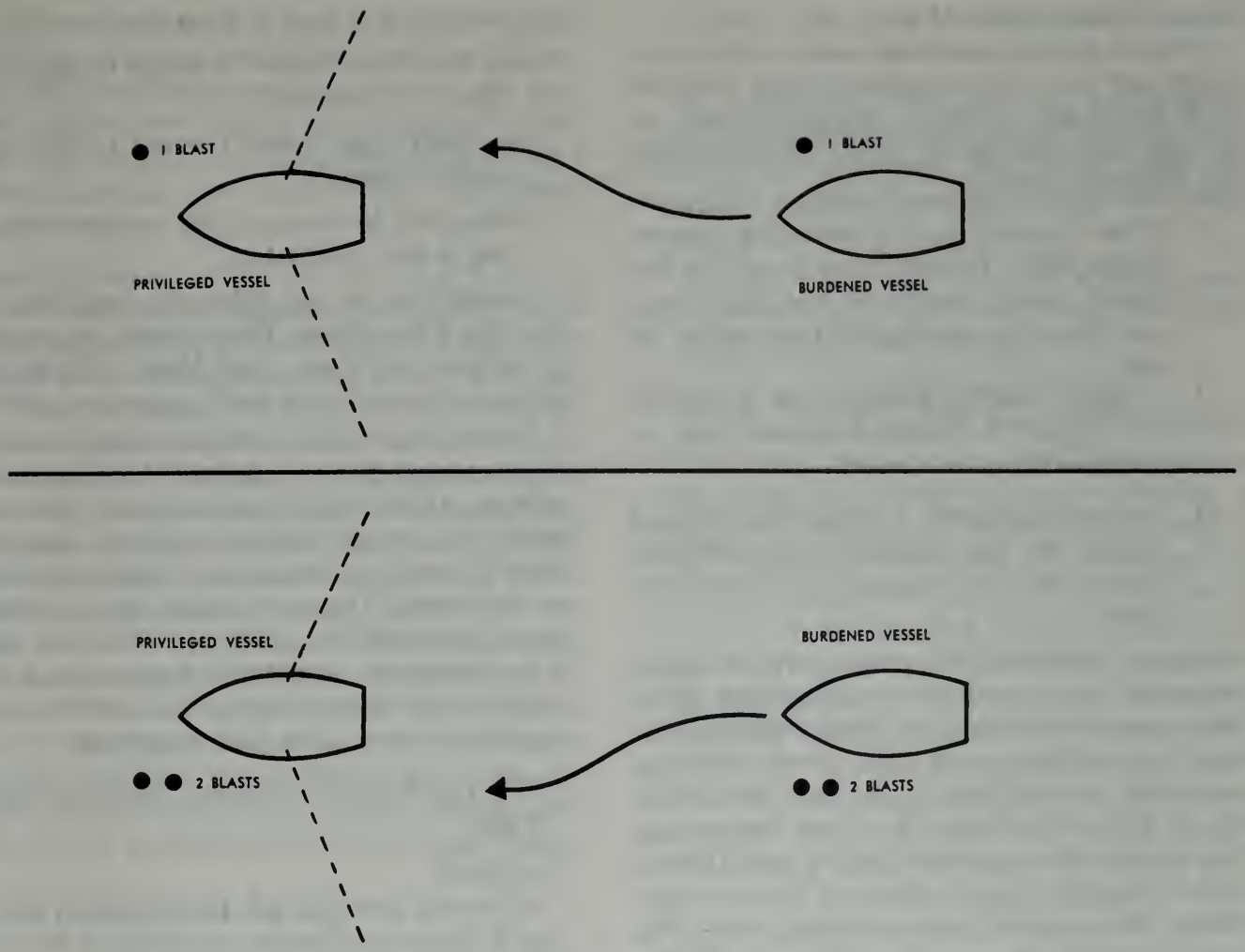


5-17 Crossing Situations Under Inland Rules

are unable to see the overtaken vessel's side lights (red or green) you should assume that you are overtaking and keep clear. During an overtaking situation, the privileged vessel (the one being overtaken) must maintain course and speed. If the burdened vessel (the one which is overtaking) wishes to pass on the privileged vessel's starboard side, she will sound one short blast (1 second). If the privileged vessel agrees to the starboard passage, she will answer with one short blast. If the burdened vessel desires to pass on the privileged vessel's port side, she will sound two short blasts. Again, if the privileged vessel agrees to the port passage, she will answer with two short blasts. If for some reason it is not safe for the overtaking vessel to pass on the side signalled for, the privileged vessel will sound the danger signal. In this case it is usually not necessary for both vessels to stop. They simply continue to exchange signals until they have agreement on which side the passage will be made. In no case may a vessel answer a signal with a different signal. A signal of one short blast must be answered with one short blast or the danger signal. It is illegal to answer one blast with two, or two blasts with one. This is known as a "cross signal." It keeps everyone in doubt concerning the exact intentions of the other vessel and is quite dangerous.

Power Vessels in Narrow Channels and Bends

In a narrow channel, every power vessel shall keep to the right side of the channel if it is safe and practicable to do so. When a power vessel is nearing a bend in a channel where a vessel approaching from around the bend would not be seen due to cliffs or some other obstruction, Inland



5-18 Overtaking Situations - Inland Rules

Rules require the vessel to sound one long blast at about the time she arrives one-half mile from the bend. The duration of time for a long blast is not spelled out in the Inland Rules but it is traditionally a blast of eight to ten seconds duration. If this signal is answered by a vessel around the bend, both vessels shall immediately give and answer proper signals for meeting and passing. If the signal is not answered, the channel is to be considered clear and the vessel giving the signal may act accordingly.

A vessel leaving her berth shall give the same signal as a vessel nearing a bend.

In narrow channels, a power vessel of 65 feet or less in length shall not hamper the safe passage of a vessel which can navigate only inside such channel. Large deep-draft ships are difficult to maneuver and almost impossible to stop in response to situations imposed upon them by other vessels while they are navigating in a narrow channel. The Inland Rules give these larger vessels the right-of-way in narrow channels. This is only common sense.

Right-of-Way of Fishing Vessels

All fishing vessels which are fishing with nets, lines or trawls are privileged under the Inland Rules. Vessels fishing in this manner may be underway or at anchor. In any case, it's dangerous to approach too close, so you should keep well clear. If you happen to be streaming a jig from astern in the hope that you might catch a fish, this fact does not make your boat a fishing vessel under the rules. You will be able to tell a fishing vessel by the fact that she must display a basket aloft where it can best be seen.

Sailing Vessel Right-of-Way

When a power-driven vessel and a sailing vessel (under sail only) are proceeding in such directions as to involve risk of collision, the power-driven vessel shall keep clear of the sailing vessel except in the following situations:

1. When a sailing vessel is overtaking a power-driven vessel, the overtaken vessel (in this case the power vessel) has the right-of-way, and the sailing vessel shall keep out of the way.
2. A sailing vessel shall keep clear of any vessel engaged in fishing with nets, lines or trawls.
3. In a narrow channel, a sailing vessel shall not hamper the safe passage of a power-driven vessel which can navigate only inside such channel.

Sailing vessels do not exchange whistle signals with each other, nor do they exchange such signals with a power vessel. Sailboat skippers should realize that, even though power boats are far more maneuverable than sail boats, power boats do not have power brakes. It is foolhardy to defy fate by tacking immediately under the bow of a power boat in the comforting assurance that you have the right-of-way. The power boat's transmission could fail to engage in full reverse and an accident could very likely result. Having the right-of-way is small comfort when viewed in the light of a damaged hull and possible injury to those aboard.

Sound Signals Under Inland Rules of the Road

On Inland waters, sound signals required when meeting, crossing or overtaking are signals of intent and assent. The vessel which signals first does so to indicate her proposed action. When the signal is answered by the other vessel, she is indicating that she understands the signal and that she agrees with the proposed maneuver by the other vessel and will govern her own actions accordingly. Only after this agreement is reached does either vessel change course.

Sound signals of intent and assent are only exchanged between power vessels in sight of one another, and then only when they are close enough that a risk of collision might arise.

All sound signals under Inland Rules are sounded on the whistle. Whistle signals have many meanings, such as in a head to head situation.

One short blast means "I intend to alter my course to starboard."

Two short blasts mean "I intend to alter my course to port."

Three short blasts mean "My engines are going at full speed astern."

Inland Rules do not define the exact length of time for a short blast. These signals are intended to be given as "short, rapid blasts." A period of about one second each would appear to suffice.

When power vessels are approaching each other, if either vessel fails to understand the course or intention of the other, from any cause, the vessel which is in doubt shall immediately signify the same by sounding four or more short rapid blasts on the whistle. This is the danger signal (or doubt signal) under the Inland Rules. When this signal is heard from any vessel which is approaching, both vessels should stop and not proceed until the proper signals have been given and understood.

Conduct in Restricted Visibility Under the Inland Rules

Fog Signals

All vessels, power or sail, are required by the Inland Rules to sound proper fog signals in fog, mist, falling snow or heavy rain storms, whether by day or night. Power vessels sound fog signals on the whistle; sail vessels sound fog signals on the fog horn.

A power vessel underway shall sound one prolonged blast on the whistle at least every minute.

Towing vessels sound a series of three blasts in succession, namely, one prolonged blast followed by two short blasts. A vessel being towed may give the same signal.

A sailing vessel underway shall sound, at intervals of not more than one minute, the following signals on the fog horn.

If on the starboard tack — one blast.

If on the port tack — two blasts in succession.

If the wind is abaft the beam — three blasts in succession. The rules do not specify the length of time for each blast.

Vessels at Anchor

When at anchor, a vessel shall ring the bell rapidly for at least five seconds at intervals of not more than one minute. This is not required of vessels not over 65 feet in length when anchored in a special anchorage area as specified by the Secretary of the Army.

Speed in Fog

In conditions of impaired visibility, all vessels shall proceed at a moderate speed, having careful regard to the existing circumstances and conditions. A vessel which hears the fog signal of another vessel apparently ahead of her beam shall, as far as the circumstances of the case permit, stop her engines and then navigate with caution until danger of collision is over. In conditions of reduced visibility, the speed shall be governed to a great extent by the visible distance. It would appear logical to give one-half of the visible distance to the other vessel. Under this assumption, any vessel underway in fog should be able to stop in half of her visible distance. This speed, that is a speed at which you would be able to stop in half of the visible distance, would be the *maximum* speed allowed under the rules of good seamanship in the circumstances.

Great Lakes Rules of the Road

Power Vessels Meeting in Narrow Channels and Rivers

When two power vessels meet (going in opposite directions) in narrow channels where there is a current, the "less maneuverable" or descending vessel has the right-of-way. The privileged vessel is required to signal as to which side she plans to take, which signal shall be given at about the time the two vessels approach to within one-half mile of each other. If the privileged vessel elects to pass the burdened vessel port-to-port, she shall signal this intention by sounding one "distinct blast" on the whistle. This shall be promptly answered by the burdened vessel by a similar blast on her whistle. If the privileged vessel elects to pass starboard-to-starboard, she shall sound two distinct blasts on her whistle, which shall also be promptly answered by the burdened vessel by two distinct blasts. These signals could be considered signals of intent and understanding in the sense that the privileged vessel signals her intention and the burdened vessel signals her understanding of the privileged vessel's intentions.

In all channels of less than 500 feet in width, when power vessels proceeding in opposite directions are about to meet, both vessels shall slow down to a moderate speed, according to the circumstances.

A power or sail vessel of 65 feet or less in length shall not hamper the safe passage of a vessel which can navigate only inside that channel.

Vessels Overtaking in Narrow Channels

In channels less than 500 feet in width, the rules do not permit one vessel to overtake and pass another unless the overtaken vessel is disabled or signals her permission for the overtaking vessel to pass. If the overtaking vessel desires to pass the overtaken vessel's starboard side she shall signal by sounding one distinct blast on the whistle. If the overtaken vessel agrees to the starboard passing, she shall answer with one distinct blast. If the overtaking vessel desires to pass the overtaken vessel's port side, she shall signal by sounding two distinct blasts on the whistle. If the overtaken vessel agrees to the port passing, she shall answer with two distinct blasts. If the overtaken vessel decides that either passing is unsafe, she shall answer by sounding several short and rapid blasts on the whistle, not less than five. In this case, the overtaking vessel may not pass until permission has been received from the overtaken vessel by a properly answered whistle signal.

Special Rules for the St. Mary's River

Special anchorage and navigation requirements for the St. Mary's River in Michigan supplement the general rules and regulations applicable to vessels on the Great Lakes. These are set forth in a separate section of the Great Lakes Pilot Rules (contained in Coast Guard publication CG-172.) and will not be enumerated here.

Power Vessels Meeting End-on

When two power vessels are meeting end-on or head-on so as to involve risk of collision, neither vessel shall have the right of way and each shall sound one distinct blast on the whistle and shall alter her course to starboard so that each shall pass on the port side of the other.

If the vessels are passing in opposite directions

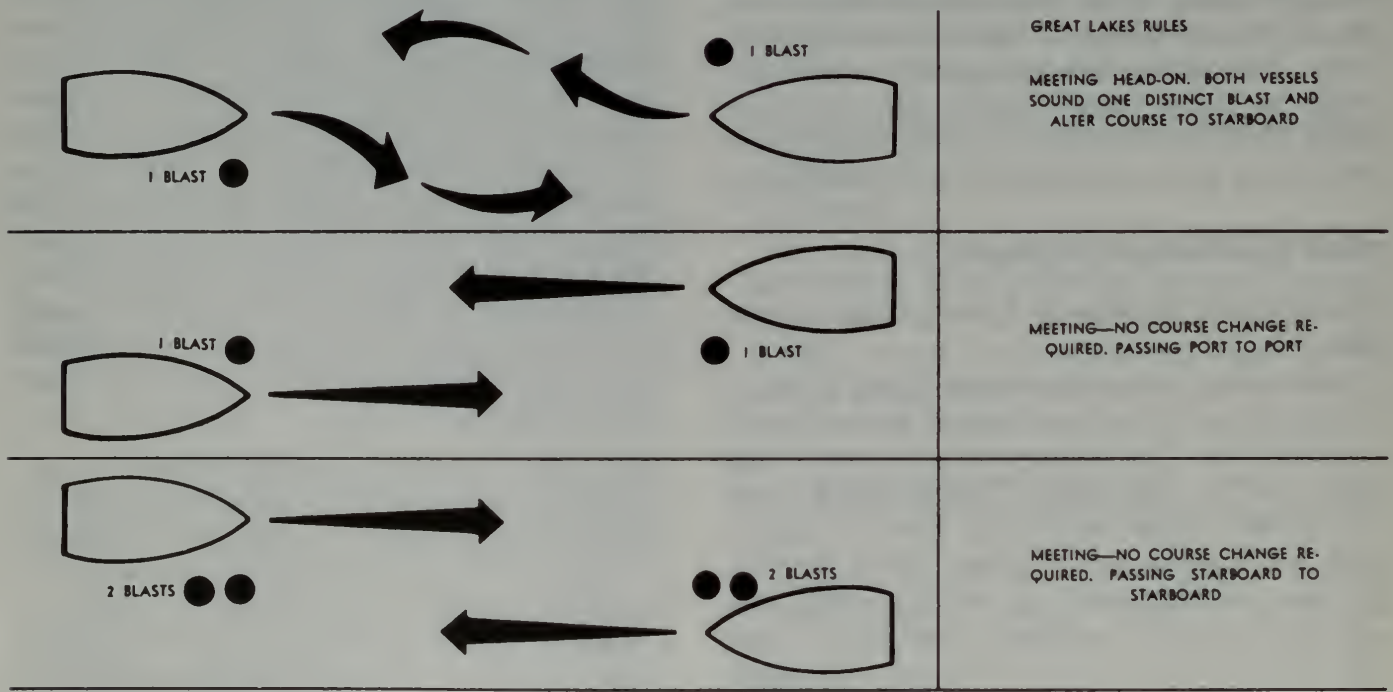
and an alteration of course will not be required in order to pass safely, whistle signals indicating course must be given and answered. If the vessels will pass port-to-port, each shall sound one distinct blast on the whistle. If they will pass starboard-to-starboard, each shall sound two distinct blasts on the whistle. These signals shall be sounded as the vessels approach within one-half mile of each other.

Power Vessels Crossing

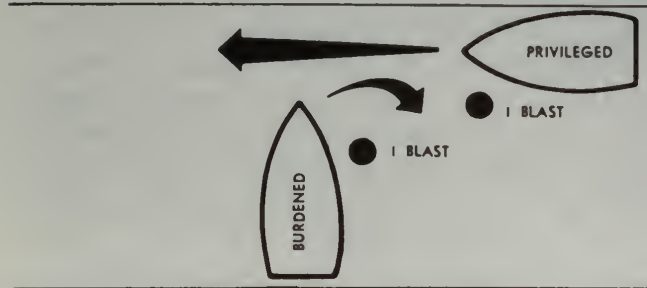
When two power vessels are crossing so as to involve risk of collision, the vessel which has the other on her starboard side shall keep out of the way of the other. The vessel having the right of way shall blow one distinct blast on the whistle as a signal of her intention to cross the bow of the other, holding her course and speed, which signal shall be promptly answered by the other vessel by one distinct blast on the whistle as a signal of her intention to direct her course to starboard so as to cross the stern of the other vessel or otherwise keep clear. If for some reason it is not possible for both vessels to comply with each other's signals, this shall be made apparent by blowing the danger signal (five short rapid blasts) and both vessels shall stop, engines backed if necessary, until signals for passing with safety are made and understood.

Power Vessels Overtaking

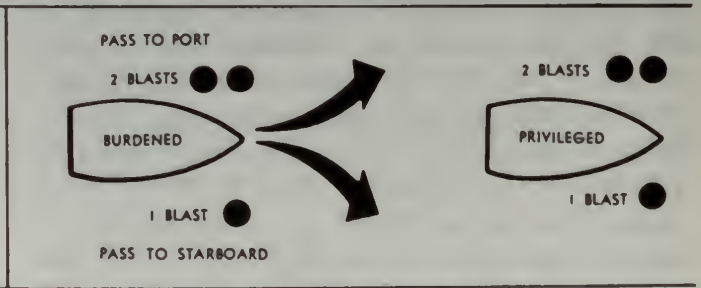
When one power vessel desires to overtake another by passing the overtaken vessel's starboard side, she shall sound one distinct blast on the whistle to signal this desire and, if the overtaken vessel answers with one blast, she shall direct her course to starboard and pass the other vessel. If the overtaking vessel desires to pass the overtaken vessel's port side, she shall sound two distinct blasts and, if the overtaken vessel answers with two blasts, she shall direct her course to port and pass the other vessel. If the vessel ahead does not think it



5-19 Meeting Situations



5-20 Crossing Situation



5-21 Overtaking Situation

safe for the vessel astern to pass at that time, she shall immediately sound the danger signal of several short and rapid blasts on the whistle, not less than five. The vessel astern shall not attempt to pass until the overtaken vessel deems it safe to do so and signifies this by a properly answered whistle signal.

Sailing Vessel Right-of-Way

When a steam vessel and a sailing vessel (under sail alone) are proceeding in such directions as to involve risk of collision, the power vessel shall keep out of the way of the sailing vessel except in the following situations:

1. When a sailing vessel is overtaking a power vessel, the overtaken vessel has the right-of-way and the sailing vessel shall keep out of the way
2. In a narrow channel, a sailing vessel shall not hamper the safe passage of a power-driven vessel which can navigate only inside such channel.

Sailing vessels do not exchange whistle signals with each other, nor do they exchange such signals with power vessels. Sailboat skippers should realize that, even though power boats are far more maneuverable than sail vessels, power boats do not have power brakes. It is foolhardy to defy fate by tacking immediately under the bow of a power vessel in the comforting assurance that you have the right-of-way. The power vessel's transmission could fail to engage in full reverse and an accident could very likely result. Having the right-of-way is small comfort when viewed in the light of a damaged hull and possible injury to those aboard.

Sound Signals

On the Great Lakes, sound signals are given in all weathers, regardless of visibility. Every power vessel which receives a signal shall promptly answer such signal with the same signal or sound the danger signal. Passing signals are required to be given and answered regardless of whether or not a change of course is to be made. Signals must be sounded at about the time the vessels are within one-half mile of one another. "Cross signals" such as answering one blast with two, or two blasts with one, are forbidden under the rules. If a signal is not understood, or if the other vessel's actions are not understood or deemed unsafe, the danger signal should be sounded and both vessels should observe the rule applying thereto.

These signals shall be sounded on the whistle, and are as follows:

One distinct blast—"I am altering my course to starboard."

Two distinct blasts—"I am altering my course to port."

Five or more rapid blasts—The danger signal.

One long blast of at least 8 seconds—Used by a vessel within one-half mile of a bend in a channel, or by a vessel leaving her berth.

NOTE: Under Great Lakes Rules, "distinct blasts" should not be confused with "short blasts" of one second's duration. The one second blast is considered too short and, although the length of the blast is not specified, a blast of from two to three seconds would appear to satisfy the requirements.

Conduct in Restricted Visibility

Fog Signals

In restricted visibility, whether by day or night, fog signals shall be sounded on the whistle as follows:

A power vessel underway shall sound three successive distinct blasts on the whistle at intervals of not more than one minute.

A vessel in tow shall, at intervals of one minute, sound "four bells" on the bell in the same manner as "four bells" is struck indicating time. Strike the bell twice in quick succession, wait a short interval, and strike the bell twice again in quick succession.

A sailing vessel underway shall sound, at intervals of not more than one minute, the following signals on the fog horn:

If on the starboard tack with wind forward of the beam—one blast

If on the port tack with wind forward of the beam—two blasts

If the wind is abaft the beam on either side—three blasts

The rules do not describe the length of these blasts.

Vessels at Anchor

When at anchor or aground in or near a channel

or fairway, a vessel shall ring the bell rapidly for three to five seconds at intervals of not more than two minutes. In addition, such vessel shall sound one short blast, two long blasts and one short blast in quick succession on the whistle at intervals of not more then three minutes.

Speed in Fog

Every vessel shall, in thick weather by reason of fog, mist, falling snow, heavy rain or other causes, proceed at a moderate speed. If a fog signal of another vessel is heard from a direction apparently not more than four points from right ahead, the vessel hearing such signal shall at once reduce speed to bare steerageway and navigate with caution until the vessels have passed one another. In reduced visibility, it would appear logical to give one-half of the visible distance to the other vessel. Under this assumption, if two vessels are coming directly at one another, each would be able to stop in half of the visible distance. "Moderate speed" under Great Lakes Rules would appear to be satisfied under these conditions.

Western Rivers Rules of the Road

Power Vessels Meeting End-on

When two power vessels are meeting end-on, or nearly so, so as to involve risk of collision, it shall be the duty of each to alter course to starboard sufficiently to pass each on the port side of the other, if this can be done in safety. This maneuver shall require an exchange of one-blast whistle signals when the vessels are no less than one-half mile apart. Either vessel may blow the first signal and the other vessel shall promptly answer.

Power Vessels Meeting at the Confluence of two Rivers

When two power vessels meet at the confluence of two rivers, the vessel which has the other to port shall give the first signal. In no case shall the vessels attempt to pass each other until there has been a thorough understanding as to the side each vessel shall take.

Power Vessels Meeting in Narrow Channels or Rivers

When an ascending vessel is approaching a descending vessel on a river, the ascending vessel shall give the first signal by one blast of the whistle if she desires to pass on the port side of the descending vessel. The ascending vessel shall give two blasts if she desires to pass on the starboard side of the descending vessel. These signals shall be promptly answered by the descending vessel if the maneuver is considered safe. Each shall be governed accordingly. If the descending vessel deems it dangerous to do so, she shall signify the fact by giving the danger signal, a series of rapid blasts (not less than four) on the whistle. It then shall be the duty of the ascending vessel to answer by a similar danger signal. Engines of both vessels shall then be stopped and backed if necessary until signals for passing are given, answered and understood, with the descending vessel having the right-of-way. After the danger signals have been mutually given, the descending vessel must then indicate, by whistle, the side which she desires for passing and the ascending vessel shall govern herself accordingly.

Power Vessels Crossing

When power vessels are crossing so as to involve risk of collision, the vessel on the port side of the other shall keep out of the way of the other. Both vessels shall exchange one-blast signals (either blowing first) to signify intentions to comply with the Rules.

If conditions are such as to prevent compliance with these signals, the misunderstanding or objection shall be made apparent by the danger signal, four or more short and rapid blasts of the whistle, and both vessels shall be stopped and backed if necessary until signals for passing in safety are given, answered and understood.

Every steam vessel when approaching another vessel so as to involve risk of collision shall slacken her speed, or, if necessary, stop and reverse.

Power Vessels Overtaking

Any vessel overtaking another shall keep out of the way of the overtaken vessel, until she is past and clear, and no subsequent altering of course shall make the overtaken vessel a crossing vessel. A vessel being overtaken shall in no way attempt to cross the bow or the head of the tow of an overtaking vessel.

A vessel approaching from the stern shall be considered to be an overtaking vessel and, if desiring

to pass on the overtaken vessel's starboard side, shall indicate her intentions by one blast on the whistle. If she desires to pass on the port side, she shall indicate her intentions by two blasts on the whistle. In no case shall she attempt to pass until the overtaken vessel has answered her signals to show she understands and that the way ahead is clear. If the overtaken vessel answers the passing request with a danger signal, the overtaking vessel shall blow acknowledgement (the danger signal) and wait for the overtaken vessel to signal a safe side.

Vessel Leaving a Berth or Anchorage

A vessel leaving her berth or anchorage shall give three distinct blasts on her whistle and approaching vessels shall take care to ascertain her course and, at that time, exchange the proper signals for passing. Keep in mind that this is a special circumstance covered by the General Prudential Rule (Rule 25) and the Rule of Good Seamanship (Rule 26) until the undocking vessel has cleared the dock and set her course.

Power Vessels in River Bends

Whenever a power vessel ascending or descending a river approaches a bend she shall, when the head of her tow is 600 yards from such bend, give three distinct blasts on the whistle, which shall be answered by vessels approaching from the other side of the bend. Upon hearing such an answer, she shall proceed with caution until the vessels are in sight of each other and the proper signals for passing have been exchanged.

Special circumstances may render a departure from these rules necessary to avoid immediate danger and in such case neither vessel shall have the right-of-way and both shall navigate with caution until such danger is over.

Special Whistle Light

Most vessels shall carry, in addition to regular running lights, an amber light high enough above the pilot house to have an uninterrupted view from approaching vessels, which will light in conjunction with the blowing of the whistle.

Special Caution for Small Craft

In presenting this material concerning Rules of the Road for Western Rivers, much information has been necessarily omitted principally because of the fact that great emphasis is placed on rules governing commercial craft. This omission in no way implies that the operators of pleasure vessels should attempt to play "Rules of the Road" with heavily laden vessels or large tows and force their will upon such commercial craft, regardless of which vessel may have the right-of-way.

Burden and Privilege on Western Rivers

On Western Rivers, burdened vessels are as follows:

Any vessel (sail or power) which is overtaking another.

Any power vessel crossing a river.

Any power vessel approaching another from the other vessel's port side.

Any ascending power vessel when meeting another vessel in a narrow channel or confined space such as a bridge; the ascending vessel shall hold her position at slow or stop, permitting the descending vessel a clear passage. (It's easier to hold a vessel against the current.) Vessels ascending a river will, unless a clear understanding by an exchange of whistle signals is reached, give the choice of passing side to the descending vessel.

Any vessel (sail or power) of 65 feet or less in length that can maneuver easily shall not hamper the passage of a large vessel or vessel with tow that is ascending or descending a river.

A sailing vessel does not have the right to hamper the safe passage of a large vessel or vessel with tow that is ascending or descending a river.

Sound Signals

On the Western Rivers, the following sound signals shall be used:

One blast—"I intend to alter my course to starboard."

Two blasts—"I intend to alter my course to port."

NOTE: The duration of the blasts is not specified. These are signals of intent and assent. Each signal

must be answered with a similar signal or the danger signal.

However, a vessel descending a river and meeting another vessel may sound the danger signal (four or more short rapid blasts) in reply to an ascending vessel's one or two-blast signal and then indicate by a whistle signal on which side she wishes to pass.

Four or more short, rapid blasts—The danger signal. Any vessel, upon hearing the danger signal, shall make all efforts to hold her position and not proceed until she has a clear understanding of what danger exists, and act accordingly.

Vessels approaching a bend in a river shall, when 600 yards distant, sound three distinct blasts on the whistle, to be answered by any other vessel approaching from the other direction.

Conduct in Restricted Visibility

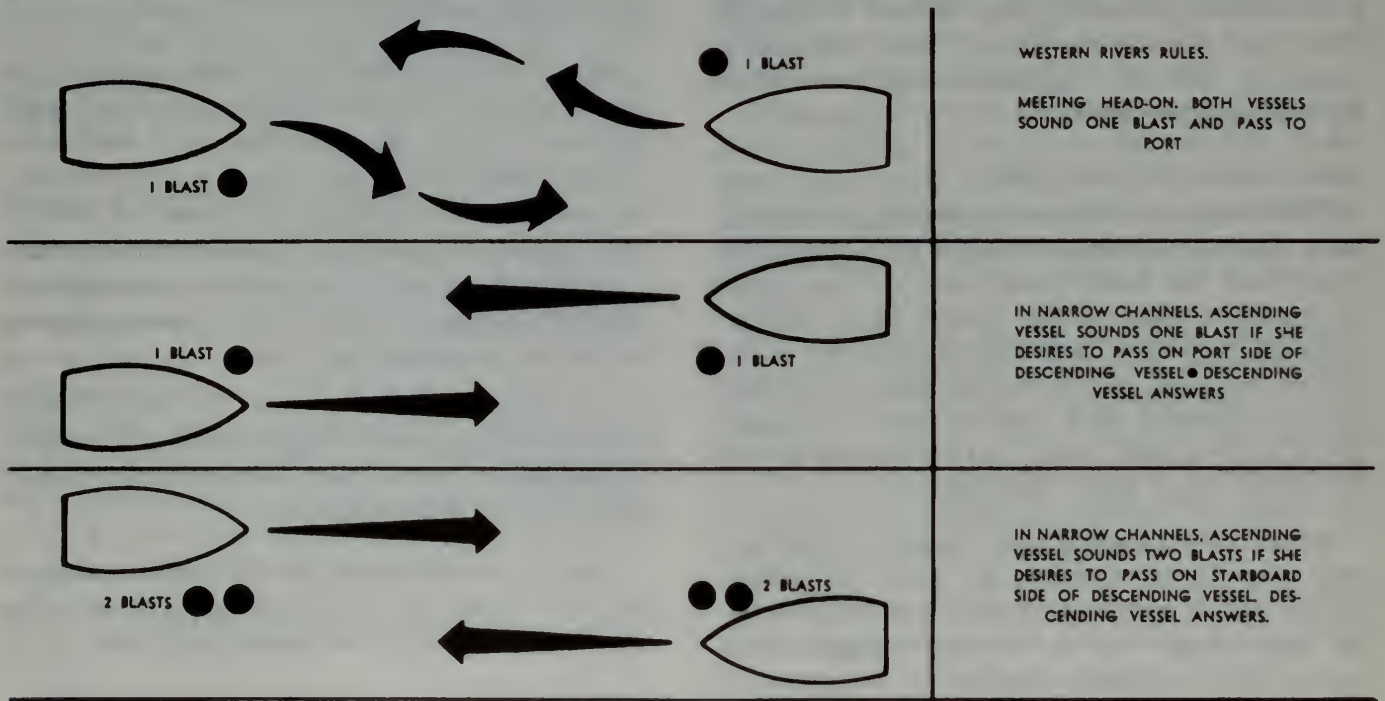
Fog Signals

In fog, mist, falling snow or heavy rainstorm or any other condition of restricted visibility, whether by day or night, the fog signals to be used shall be as follows:

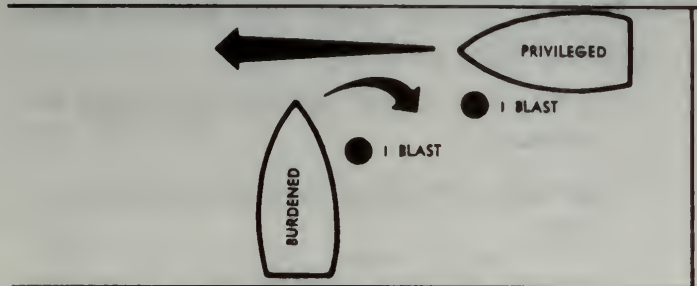
A vessel underway and towing another vessel or vessels shall sound at intervals of not more than one minute, three distinct blasts of the whistle of approximate equal length.

A vessel underway *without* a tow shall sound at intervals of not more than one minute, three blasts of the whistle, the first two of equal length and the last blast to be longer (two short, 1 long).

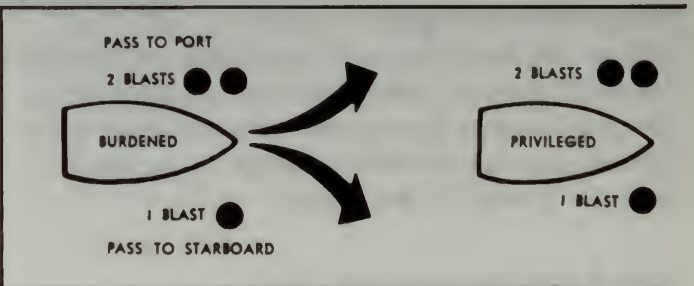
A vessel with or without a tow, lying to, meaning to hold her position near or against the bank by using her engines, or temporarily moored to the



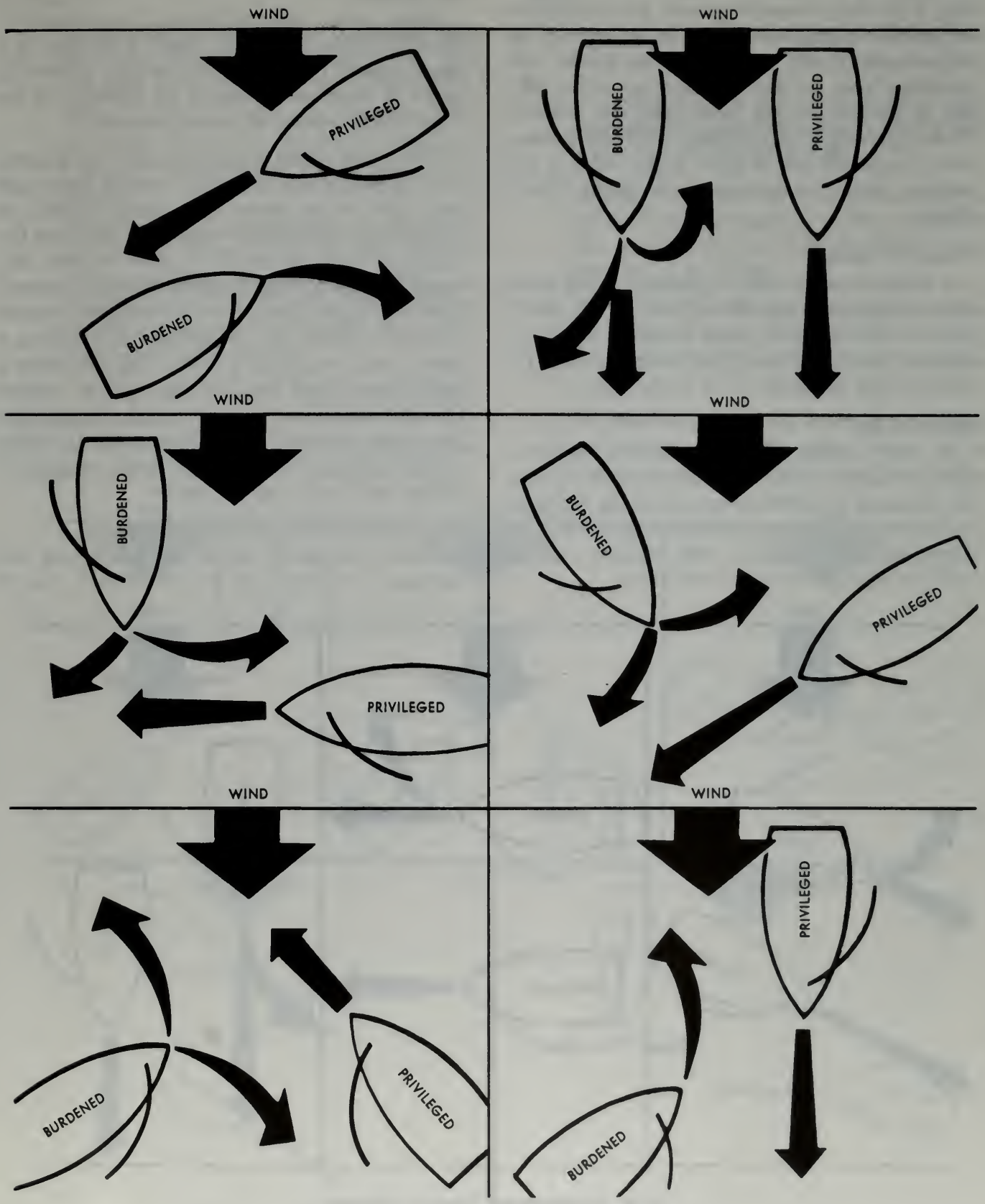
5-22 Meeting Situations



5-23 Crossing Situation



5-24 Overtaking Situation



5-25 International Rules for Sailboats

bank, when a fog signal or other sound indicating the approach of another vessel is heard shall, if lying to the right descending bank, give one tap on her bell to indicate her presence, at intervals of not more than one minute. If lying to the left decending bank, she shall give two taps on her bell, also at intervals of not more than one minute. These signals shall be continued until the passing vessel has passed and is clear. Right and left descending bank are determined by facing downstream.

Vessels at Anchor

A vessel at anchor shall, at intervals of not more than one minute, ring the bell rapidly for about five seconds. Vessels in special anchorages, as designated by the Secretary of the Army, are not required to ring bells.

Speed in Fog

A vessel underway, under restricted visibility, shall proceed at a moderate speed and, upon hearing the fog signal of another vessel apparently ahead of her beam, shall at once reduce her speed to bare steerageway and navigate with extreme caution until the vessels have passed each other.

Rules of the Road for Sailing Vessels

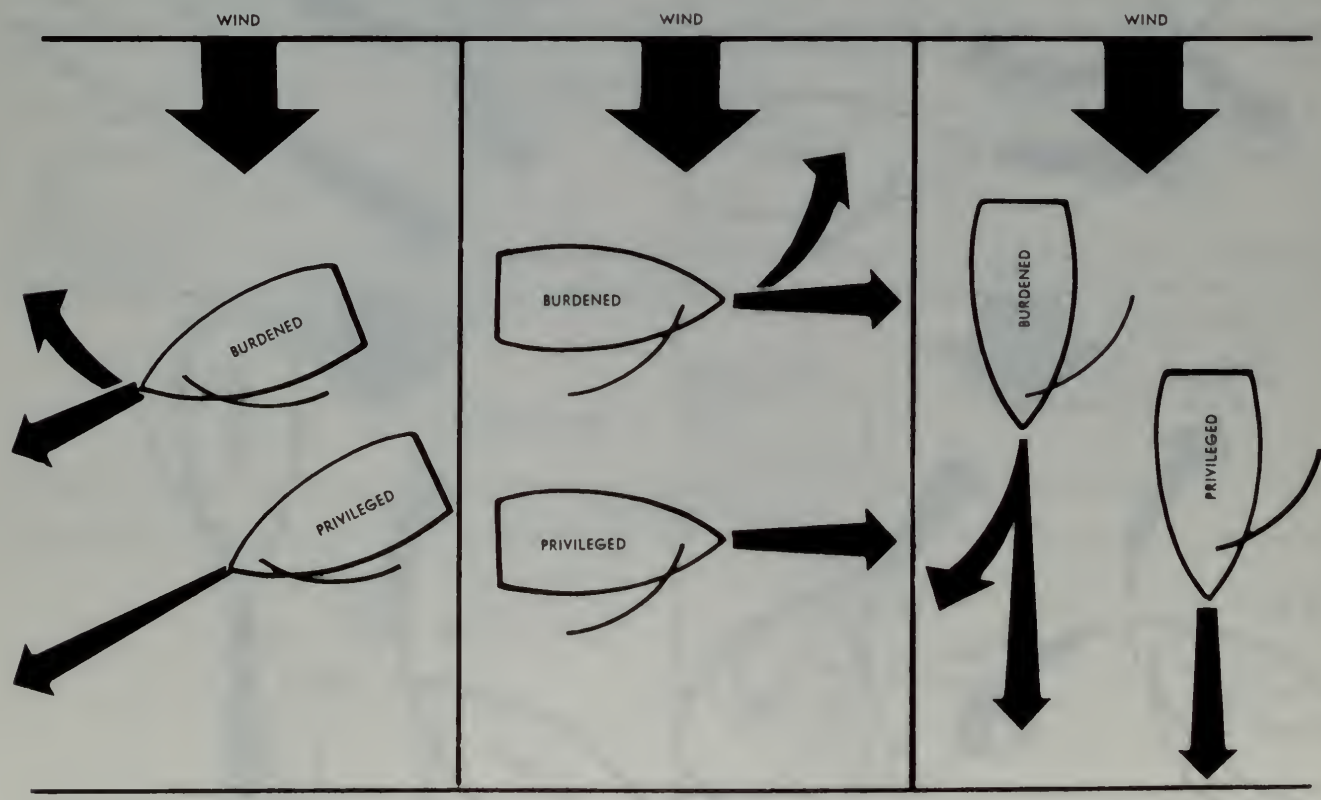
Introduction

Sailing vessels do not indicate their course or intended action in passing a vessel of any type by a whistle signal. The right-of-way between two sailing vessels is determined solely by the direction of the wind in reference to the vessels' courses.

When two sailing vessels approach one another so as to involve risk of collision, one of them shall keep clear of the other. The vessel required to keep clear is the burdened vessel, and the other the privileged vessel which is required to hold her course and speed. Sailing vessels (under sail alone) have the right-of-way over power-driven vessels except: (1) when the sailing vessel is overtaking a power vessel, or (2) in a narrow channel where a sailing vessel shall not have the right to hamper the safe passage of any vessel which can navigate safely only within such channel, and (3) sailing vessels shall keep clear of any vessels engaged in fishing with nets, lines or trawls.

International Rules for Sailing Vessels

When two sailing vessels are approaching one another so as to involve risk of collision, one of



5-26 International Rules for Sailboats

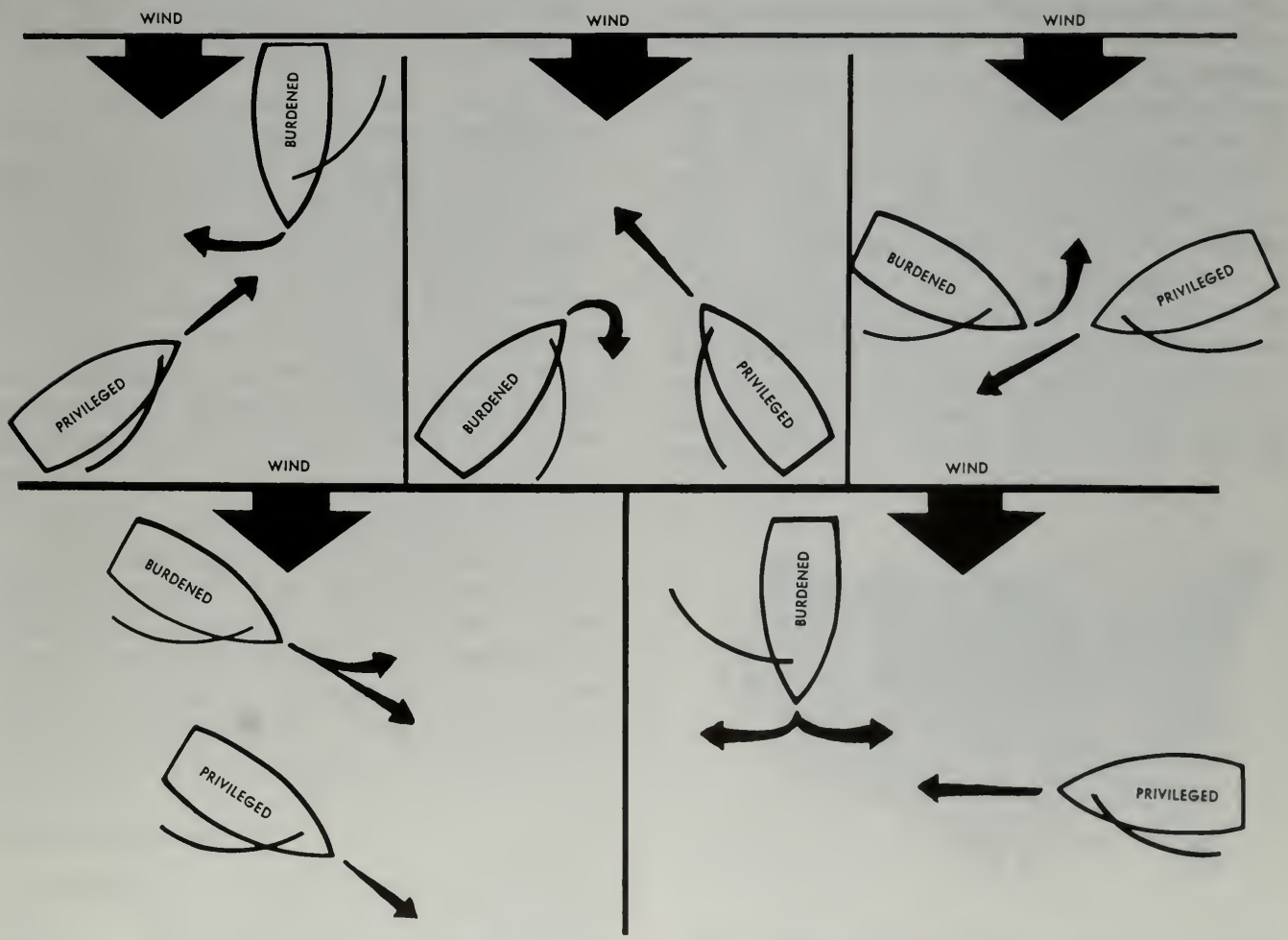
them shall keep out of the way of the other as follows:

1. When each has the wind on a different side, the vessel which has the wind to the port side shall keep out of the way of the other.
2. When both have the wind on the same side, the vessel which is to windward shall keep out of the way of the vessel which is to leeward.
3. For the purposes of these rules the windward side shall be deemed to be the side opposite to that on which the mainsail is carried. On square-rigged vessels, it shall be deemed to be the side opposite to that on which the largest fore-and-aft sail is carried.

Inland, Great Lakes and Western Rivers Rules for Sailing Vessels

When two sailing vessels are approaching one another so as to involve risk of collision, one of them shall keep out of the way of the other as follows:

1. A vessel which is running free shall keep out of the way of a vessel that is close hauled.
2. A vessel which is close hauled on the port tack shall keep clear of a vessel which is close hauled on the starboard tack.
3. When both vessels are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.
4. When both vessels are running free with the wind on the same side, the vessel which is to windward shall keep out of the way of the vessel which is to leeward.
5. A vessel which has the wind aft shall keep out of the way of the other vessel. NOTE: *This rule does not apply to the Great Lakes.*



5-27 Inland, Great Lakes and Western Rivers Rules for Sailing Vessels.

CHAPTER 6

Aids to Navigation

Introduction

Along the coasts and navigable waters of the United States and its possessions, there are thousands of devices to give a mariner his exact position at all times, in any weather, in relation to the land and to hidden dangers. These devices range from steel and concrete structures, such as buoys and lighthouses, to invisible beacons of an electronic nature such as radiobeacons and LORAN. They are all designed for one purpose — aiding seamen.

Aids to navigation assist mariners in making landfalls when approaching from overseas, mark isolated dangers, make it possible for vessels to follow the natural and improved channels, and provide a continuous chain of charted marks for coastal piloting. As all aids to navigation serve the same general purpose, such structural differences as those between an unlighted buoy and a lightship, or a lighthouse and a radiobeacon, are solely for the purpose of meeting the conditions and requirements for the particular location at which the aid is to be established.

All aids to navigation (except private aids) in the waters over which the United States has jurisdiction are designed, built and maintained by the United States Coast Guard. It is a tremendous job. There are more than 40,000 aids to navigation in U.S. waters alone. This responsibility has been executed well; and today the United States has the best system of aids to navigation in the world.

The Lateral System

The waters of the United States are marked for safe navigation by the lateral system of buoyage. This system employs a simple arrangement of colors, shapes, numbers and light characteristics to show the side on which a buoy should be passed when proceeding in a given direction. The characteristics are determined by the position of the buoy with respect to the navigable channels as the channels are entered from seaward toward the head of navigation.

As all channels do not lead from seaward, arbitrary assumptions must at times be made in order that the system may be consistently applied. The characteristics of buoys are based on the assumption that proceeding in a southerly direction along the Atlantic coast, in a northerly and westerly direction along the Gulf coast, in a northerly direction on the Pacific coast, and in a westerly and northerly direction on the Great Lakes (except Lake Michigan) and in a southerly direction in Lake Michigan is proceeding from seaward. On the Intracoastal Waterway, proceeding in a general southerly direction along the Atlantic coast, and in a general westerly direction along the Gulf coast is considered as proceeding from seaward. On the

6-1 Arbitrary Direction Under Lateral System

Mississippi and Ohio Rivers and their tributaries, the aids to navigation characteristics are determined as proceeding from sea towards the head of navigation although local terminolgy describes "left bank" and "right bank" as proceeding with the flow of the river.

In addition to the lateral system of buoyage, several special purpose buoyage characteristics, which have no lateral significance, are utilized to mark dredging areas, quarantine areas, fish net areas, anchorages, race courses, experiments or tests.

Buoys

The primary function of buoys is to warn the mariner of some danger, some obstruction or change in the contours of the sea bottom, or to delineate channels leading to various points, so that he may avoid dangers and continue his course safely. The utmost advantage is obtained from buoys when they are considered as marking definitely identified spots, for if a mariner knows his precise location at the moment and is properly equipped with charts, he can plot a safe course on which to proceed. Such features as size, shape, coloring, numbering and signaling equipment of buoys are but means to these ends of warning, guiding and orienting the navigator. However, a word of caution should be included here concerning buoys and other floating aids to navigation. Buoys should not be regarded as immovable objects. They may be missing, adrift, or off the charted position due to heavy storm, unusual tides, ice, and collisions. Even buoys that are on station should be passed a reasonable distance off, since they may be necessarily located close to the shoals they mark. Therefore, boatmen should not rely completely upon the position or operation of floating aids to navigation, but should utilize bearings toward fixed objects or aids to navigation on shore whenever possible. The lights on lighted buoys may be extinguished, or sound-producing devices on sound buoys may not function. Buoys fitted with bells, gongs or whistles which are activated by wave action do not produce sounds at regular intervals. Principally for this reason, their positive identification is not always possible.

6-2 Placing Aid to Navigation on Station by Coast Guard Buoy Tender

Coloring of Buoys

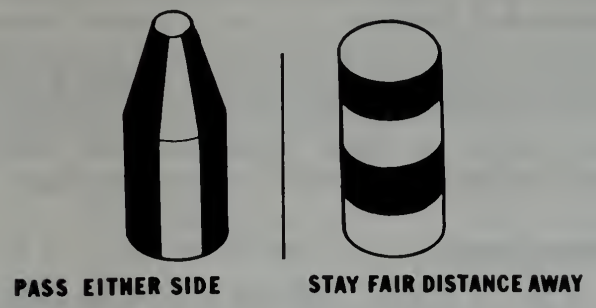
All buoys are painted distinctive colors to indicate their purpose or, in the lateral system, the side on which they should be passed. The meaning of lateral system buoys, when proceeding from seaward, as indicated by their colors, are as follows:

BLACK BUOYS mark the left side of the channel as you proceed from seaward. Black buoys are sometimes used to mark wrecks or obstructions in the channel. In this case, these buoys must be kept on the port side of your vessel as you proceed from seaward.

RED BUOYS mark the right side of the channel as you proceed from seaward. Red buoys are also used to mark wrecks or obstructions in the channel. When red buoys are used in this manner they must be kept on the starboard side of your vessel as you proceed from seaward.

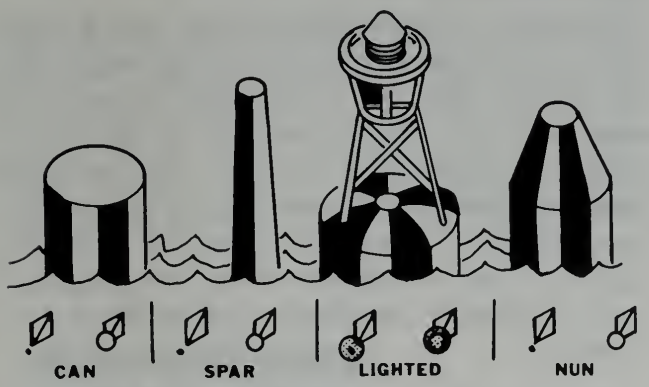
RED AND BLACK HORIZONTALLY BANDED BUOYS mark junctions in the channel, or wrecks or obstructions which may be passed on either side as you travel in the direction previously determined as "proceeding from seaward." If the topmost band is black, the preferred channel will be followed by keeping the buoy on the port side of the vessel. If the topmost band is red, the preferred channel will be followed by keeping the buoy on the starboard side of the vessel. NOTE: When approaching these red and black horizontally banded buoys from the opposite direction, as pro-

ceeding *toward* seaward, it may not be possible to pass on either side of these buoys, and the chart should always be consulted.



6-3 Vertically and Horizontally Banded Buoys

BLACK AND WHITE VERTICALLY STRIPED BUOYS mark the fairway or midchannel.



Black and white vertically striped buoys mark the fairway or mid-channel.

6-4 Lateral System.

The meaning of special purpose buoys is indicated by their colors as follows:

WHITE BUOYS mark anchorage areas.

YELLOW BUOYS mark quarantine anchorage areas.

WHITE BUOYS WITH GREEN TOPS are used in connection with dredging and survey operations.

WHITE AND BLACK ALTERNATE HORIZONTALLY BANDED BUOYS mark fish net areas.

WHITE AND INTERNATIONAL ORANGE BUOYS ALTERNATELY BANDED, EITHER HORIZONTALLY OR VERTICALLY, are for special purposes to which neither the lateral-system colors nor the special-purpose colors apply.

YELLOW AND BLACK VERTICALLY STRIPED BUOYS are used for seadrome markings and have no marine significance.

Shapes of Buoys

Buoys have many shapes, from simple spars to complicated structures. Some buoys have lights on them. Lighted buoys have no shape significance but almost all lateral unlighted buoys do have shape significance. Buoys which have shape significance are usually painted solid-red or solid-black.

NUN BUOYS are conical in shape, and are painted solid red. As mentioned previously, they indicate the right hand side of the channel upon entering from seaward.

6-5 Nun Buoy

CAN BUOYS are cylindrical in shape and are painted solid-black. These indicate the left side of the channel upon entering from seaward.

On all other buoys, the shape is of no significance. Sometimes buoys of conical or cylindrical shape are used with a paint pattern other than solid-red or solid-black. These could be horizontally banded (red and black) or vertically striped

6-6 Can Buoy

(white and black). In these instances, the paint color pattern is significant, while the shape of the buoy is not.

Other buoys (other than conical or cylindrical shaped) may be painted solid-red or solid-black and used in the place of a nun or can buoy when it is desired to direct special attention to the aid.

LIGHTED BUOYS, SOUND BUOYS AND SPAR BUOYS are not differentiated by shape to indicate the side on which they should be passed. Their purpose is indicated by color, number, and light characteristics.

Numbering of Buoys

Most buoys are given numbers, letters or combinations of numbers and letters which are painted conspicuously upon them. These markings facilitate the identification and location of the buoys on the charts.

All solid colored red or black buoys, except those in the Mississippi River Aids to Navigation System, are given numbers or combinations of numbers and letters. Other colored buoys may be given letters. Numbers increase from seaward and are kept in approximate sequence on both sides of the channel by omitting numbers where required. Odd numbers are used only on solid-black buoys. Even numbers are used only on solid-red buoys. Numbers followed by letters are used on solid-colored red or black buoys when a letter is required so as not to disturb the sequence of numbering, or on important buoys, particularly those marking isolated offshore dangers. An example of the latter case would be a buoy marked "2 DR," in which instance the number has the usual significance, while the letters "DR" indicate the place as Duxbury Reef. Letters without numbers are applied in some cases to black and white vertically striped buoys, red and black horizontally banded buoys, solid-yellow buoys, and other buoys not solid colored red or black.

In the Mississippi River System, unlighted buoys are not numbered, while the numbers on lighted buoys have no lateral significance, but indicate the number of miles from a designated point.

Lighted Buoys

Buoys of special importance must be seen at night, therefore they are equipped with lights. Lighted buoys may be used in place of either can or nun buoys. Lights are *never* used on can or nun buoys.

Lights and Reflectors

Red lights on buoys are used only on red buoys and red and black horizontally banded buoys with the topmost band red. Green lights on buoys are used only on black buoys or red and black horizontally banded buoys with the topmost band black. White lights on buoys are used on any color buoy. No special significance is attached to a white light on a buoy, the purpose of the buoy being indicated by its color, number, or its light phase characteristic.

Many unlighted buoys are fitted with optical reflectors. These greatly facilitate the locating of the buoys at night by means of a searchlight. Optical reflectors may be white, red or green, and have the same significance as lights of these colors. In addition, most modern buoys have corner radar reflectors designed into the superstructure to improve the radar response.

Light Phase Characteristics

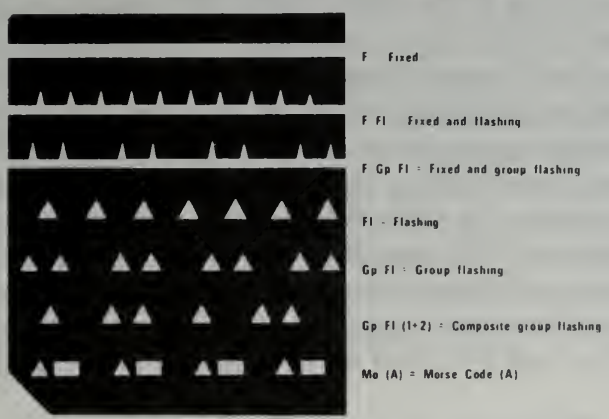
Lights on red buoys or black buoys will always be regularly flashing or regularly occulting. A flashing light flashes at a rate of *30 or less* flashes per minute. An occulting light, on the other hand, is a steady light that is interrupted by short eclipses of darkness. The time the light is "on" is more than the time it is "off." One easy method of remembering the difference between a flashing light

and an occulting light is that a flashing light "blinks on" while an occulting light "blinks off." When it is desired that a flashing light have a distinct cautionary significance, as at sharp turns or sudden constrictions in the channel, or to mark wrecks or dangerous obstructions which can be passed safely on *one side only*, the frequency of flashes will be at a rate of *60 or more* per minute. This frequency of flashes is known as a quick flashing light.

Lights on red and black horizontally banded buoys will always show a series of quick flashes (60 or more per minute) interrupted by eclipses about eight times per minute. This frequency of flashes is known as an interrupted quick flashing light. These buoys are placed at points where it is desired to indicate junctions in the channel, or wrecks or obstructions which may be passed on *either side.*

Lights on black and white vertically striped buoys consist of a short flash followed by a long flash, providing the letter "A" of the Morse Code. The series (one short and one long flash) recurs at the rate of about eight per minute. These buoys are placed at points where it is desired to indicate the midchannel or fairway. These lights are always white.

6-7 Characteristic Light Phases



Most lighted buoys are equipped with a special device which automatically controls the electric current to the light. This device causes the light to operate during the hours of darkness and to be extinguished during the daylight hours. These devices are not of equal sensitivity, therefore all lights do not come on or go off at the same time. Mariners should ensure correct identification of aids during twilight periods when some lighted aids to navigation are on while others are not.

Daybeacons (Daymarks)

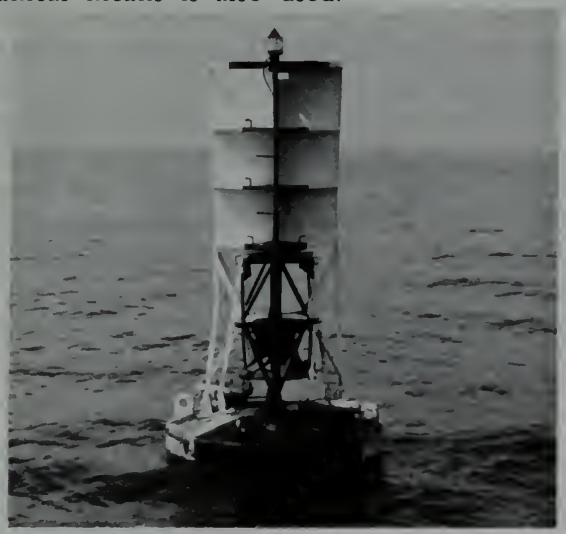
There are many aids to navigation which are not lighted. Structures (not buoys) of this type are called daybeacons. They vary greatly in design and construction, depending upon their location, and the distance from which they must be seen. Daybeacons are colored, as are lighthouses, to distinguish them from their surroundings and to provide a means of identification. Daybeacons marking the sides of channels are colored and numbered in the same manner as buoys and minor light structures; red indicating the right side entering and black the left side entering. Red day beacons will carry an even number within a red triangle or daymark and black daybeacons will carry an odd number within a black square daymark. Many daymarks are also fitted with optical reflectors to facilitate locating them at night by means of a searchlight.

6-8 Single Pile Light with Daymark

Sound Buoys

Buoys equipped with sound signals do not lose their effectiveness during low visibility. Important buoys may be bell buoys, gong buoys, whistle buoys or horn buoys. Each type has an easily recognizable sound. Bell buoys have four clappers hung loosely about the bell so that even a slight pitching of the buoy causes the bell to ring. Gong buoys differ from bell buoys in that three or four gongs of different tones, each with a separate clapper, are

rung in random order by the motion of the buoy in the sea. These signals are actuated by the motion of the sea, so one should be cautioned that they do not emit regular signal characteristics and, when the sea is calm, may emit no sound signals at all. Since the air used in whistle buoys is captured and compressed by the rising and falling of the buoy in the sea, these whistle buoys are used principally in open and exposed places where sufficient ground swell normally exists to operate the mechanism. A type of sound buoy in which a horn and sometimes a bell is sounded at regular intervals by mechanical means is also used.



6-9 Lighted, Radar Reflector, Bell Buoy

The Intracoastal Waterway System

The Intracoastal Waterway, to which is applied the system of marking about to be described, is that comparatively shallow channel lying parallel to and extending along the Atlantic and Gulf Coasts from New Jersey to the Mexican border. This special marking system is applied to the so-called "inside route" proper, and to those portions of all connecting waterways which must be crossed or followed in order to make a continuous passage.

All buoys, daybeacons and light structures marking the Intracoastal Waterway have some portion of them painted yellow. This is the distinctive coloring adopted for the waterway. Lighted buoys have a yellow band at the top. Unlighted buoys have a yellow band at approximately the midsection. Daymarks have a yellow border and pointers have a yellow band at the top. Daymarks and pointers are usually mounted on single piles. Below the yellow band on a pointer, the field is either red or black, according to the side of the channel on which it is located. When the pile carries a daymark (or daybeacon), the daymark is either a black square with a yellow border or a red triangle with a yellow border depending on whether the pile is on the port hand or on the starboard hand, as the navigator proceeds southerly along the East Coast or westerly along the Gulf Coast channels of the Intracoastal Waterway.

The coloring and numbering of buoys and Daymarks, and the color of lights on buoys and on light structures is on the same lateral system as that prevailing in other waterways. The basic rule is that RED BUOYS and Daymarks are on the right-hand side of the channel when proceeding from New Jersey toward Mexico, and BLACK BUOYS and Daymarks are on the left-hand side of the channel when proceeding in the same direction. This rule is applied in a uniform manner from one end of the Intracoastal Waterway to the other, regardless of the widely differing compass headings of the many sections, and the fact that rivers and other waterways marked on the seacoast system are sometimes followed. When the Intracoastal Waterway route coincides with another waterway, such as a river on which aids to navigation are marked from the sea to the head of navigation according to the lateral system of buoyage, special markings are used consisting of yellow squares or yellow triangles painted on a conspicuous part of such dual-purpose aids to navigation. A yellow triangle on an aid to navigation indicates that the aid must be left on the starboard side, and a yellow square on an aid indicates that it must be left on the port side, regardless of the color or number of such aid, when traversing the Intracoastal Waterway route from north to south on the Atlantic coast and from east to west along the Gulf coast.

Numbering of Intracoastal Waterway aids follows the basic rule, numbers increasing from New Jersey to Mexico. Aids are numbered in groups, usually not exceeding 200; numbering begins again at "1" at certain natural dividing points. Lights on buoys follow the standard system of red or white lights on red buoys, or green or white lights on black buoys. The color of the lights on fixed

structures also follow this general rule. Range lights, not being lateral markers, may be any of the three standard colors.

Western Rivers System

Western Rivers system includes the waters of the Mississippi River between its source and the Huey P. Long Bridge and all of the tributaries emptying thereinto and their tributaries, and that part of the Atchafalaya River above its junction with Plaquemine—Morgan City alternate waterway, and the Red River of the North.

Aids to Navigation on all of the above rivers are arranged in a numerical order. Each aid bears a number identical to the mileage of the stream at that point, as determined from the latest chart. The mileage of the aid is determined from a reference point, generally marked zero. This point may be coincident with the river mouth, or the confluence of two rivers, or at an arbitrarily determined point. Aids are located on either the left bank or the right bank, as determined when navigating the waterway in a downstream direction. Sometimes the orientation is stated in the Light List as "the left descending" or "the right descending bank."

Characteristics of Lights

Lights on the left descending bank of all waterways in the System are either fixed white or fixed red, group flashing (2) white or red, equal interval white or red, quick flashing red, or interrupted quick flashing red. Lights on the right bank descending are either fixed white or fixed green, flashing white or green, equal interval white or green, quick flashing green, interrupted quick flashing green or fixed green.

Visibility of Lights

The majority of lights on Western Rivers are visible through 360°, that is, all around the horizon, and show approximately the same candlepower viewed from any direction. For those navigational situations where superior candlepower is required, use is made of lanterns projecting light in one direction only. These are known as directional aids. They are used in two ways; (1) to supplement a 360° light by increasing candlepower in one direction only, and (2) used alone to show only superior candlepower in one direction. Directional aids are established with different degrees of horizontal spread; narrow spreads or beams are used to define long, narrow reaches; wider spreads are used where situations are not critical but a light of superior candlepower is needed. To assist in identification of the bank being marked, the lights vary in color and characteristic. Where confusing background lights require the showing of a distinctive light, recourse is made to color and flashing or occulting characteristics.

Placing of Lights and Daymarks

Lights are placed along river banks to afford the mariner assistance. Lights are spaced with due regard to their useful candlepower, the shape of the river, and the length of the reaches. Primarily, the lights serve as leading (or holding) lights at the head and foot of each crossing, supplemented by intervening lights where necessary. Secondarily, no crossing being involved, lights are placed along one bank or the other for use as passing lights. Where long reaches occur, directional lights of high candlepower are used either alone or in conjunction with a passing light at the same station, to provide a reliable leading light. The exact use of any light can only be determined from the chart, or from experience.

Vessels must keep well clear of fixed aids if there is sufficient channel to do so because there may be dangerous underwater obstructions present in the vicinity. All light structures are equipped with a number board showing the number of the aid in black figures, which is also the mileage of the river at that point.

Daymarks

Crossing daymarks are diamond-shaped wooden panels. Passing daymarks on the left descending

bank are triangular-shaped, red or white, and carry red reflectors. Passing daymarks on the right descending bank are square and carry white or green reflectors. Two boards painted white and fastened together to form an "X" are used as temporary crossing daymarks on the Missouri River.

Buoys

Buoys used to mark channels in the Mississippi River System conform to the standard lateral buoyage system of the United States. In addition, the tops of most unlighted buoys in the Mississippi River System, except horizontally banded buoys, are painted white for distinctive contrast against the shore background. All buoys carry reflectors. Buoys on the left descending side of the channel reflect red. Buoys in the right descending side of the channel reflect white, corresponding to the similar usage of reflectors on shore aids.

Lighted buoys marking wrecks show a quick flashing characteristic, sixty (60) flashes being shown per minute to indicate that particular caution is required. Colors of lights shown from buoys marking wrecks are white or red on the left descending side of the channel, and white or green on the right descending side of the channel.

Lighted buoys marking channel junctions or obstructions, which may be passed on either side, show an interrupted quick flashing characteristic; for example, a sequence of five equally spaced flashes repeated ten times per minute. The color of light shown may be white, red or green; preferably white if about midchannel, red if toward the left descending and green if toward the right descending side of the channel. However, white may be used for any situation to preclude confusion with other lighted aids or background lights.

Special attention is invited to buoys, both lighted and unlighted, painted with red and black horizontal bands. These buoys mark junctions or obstructions which may be passed on either side, the preferred side being indicated by the color of the topmost band. If such a buoy should be encountered near the apparent channel limit, it should be passed only after soundings indicate which is the proper side to pass.

In pooled rivers, buoys are normally set to mark the nine-foot contour at normal pool elevations. In open rivers, buoys are placed to mark project depths with consideration being given to the prevailing river stage.

Buoys should always be given as wide a berth as possible in passing, consistent with the size of the vessel, and the width, length and sharpness of the crossing. Buoys should always be used with caution. They may be carried off station by high water, accumulation of drift, ice, or sunk by collision or other causes. When carried off station, destroyed or removed to prevent loss, buoys are replaced on station at the earliest opportunity. Unlighted buoys may be constantly shifted with the changes in the channels. While they mark isolated dangers on the right and left descending banks, their principal use is to outline bars and shoals at the "crossings" and hence mark the channel.

Radar Reflectors

Certain aids to navigation may be fitted with special fixtures, called Radar Reflectors, which are designed to enhance their ability to reflect radar energy. In general, these fixtures materially improve the aids for use by vessels equipped with radar.

Safety Harbor and Safety Landing Markers

In the pools of the Tennessee River, safety harbors and safety landings have been provided. Safety harbors are usually deep coves or inlets adjacent to and extending back from the navigable channel. Entrance markers, on shore, consist of a direction board, about three feet by six feet. The upper limits of such harbors are marked by cross of boards. Safety landings are areas where the banks have been prepared by carefully clearing all stumps and boulders so that vessels may land safely. The upper and lower limits of these areas are marked by di-

rection boards. White direction boards indicate first class harbors, providing nine-foot depth at all pool stages. Orange direction boards indicate second-class harbors, providing depths of nine feet except at extreme drawn-down pool stages.

Emergency Lights or Sirens

When a rotating amber light is noted or a siren is heard on a waterfront facility, an emergency situation shall be considered to exist at that facility. Mariners should stand well clear of any facilities giving such signals and report the occurrence immediately to the nearest Coast Guard unit. These warning signals are required to be installed at all facilities which handle hazardous chemicals.

Locks and Dams

Before the development of our present-day system of locks and dams, some rivers were not much more than rapids, with rushing water and many dangerous obstacles. When dams were built at carefully planned locations along the rivers the water filled behind them, creating a series of pools. Since rivers flow "down-hill," each downstream pool was somewhat lower in elevation than the preceding one. These dams, of themselves, could have effectively controlled the river but they would just as effectively have blocked all river navigation. Consequently, a system of locks was devised to allow vessels to pass from one pool to another.

While locks come in all shapes and sizes, they all operate on the same principle—that water tends to seek its own level. Basically, a lock is an enclosure with accommodations at both ends (generally called gates) for allowing vessels to enter and exit the lock. By a system of culverts and valves, the water level in the lock can be made to align with the pool level of the upstream or downstream side of the lock.

A vessel traveling downstream will enter the lock when the water level is at the high (upstream) pool level. The upstream gates are then closed and the water in the lock is allowed to escape through valves and culverts. When the water level in the lock is the same as that of the downstream side of the lock, the water will cease to flow out of the lock. The downstream gates are then opened and the vessel leaves the lock to continue on its downstream voyage.

A vessel traveling upstream may then enter the lock. After the vessel is secured in the lock the downstream gates are closed and the water from the upper pool is allowed to enter the lock through valves and culverts until the water level in the lock is the same as that of the upstream pool. The upstream gates are then opened and the vessel leaves the lock to continue its upstream voyage.

You are not required to pay a fee for using most locks and any form of craft may be locked through. Single vessels are sometimes locked but more often many vessels of varying sizes are raised or lowered in a single lockage.

Priority of Vessels Through Locks

Locking through is not a first-come, first-served proposition. The Secretary of the Army has instituted a system of priorities for vessels using locks and they are allowed to pass through in the following order:

1—U.S. military craft
2—Vessels carrying U.S. mail
3—Commercial passenger vessels
4—Commercial tows
5—Commercial fishermen
6—Pleasure craft

Under certain conditions pleasure craft may be locked through with other vessels having a higher priority, provided that no delay is occasioned thereby and the safety of other craft is not jeopardized. This is done to utilize the capacity of the lock to its maximum.

Lock Signals

Since the signals used on locks may be lights, whistles or other devices, no attempt will be made here to describe them in detail. If you normally cruise on a certain section of a particular waterway, you should obtain a copy of the local regulations in force in your waters. Your course instructor will tell you which set of regulations apply and where you will be able to get them. These regulations contain, among other things, signals displayed and utilized by locks and also the proper signals you will be required to sound on your boat's whistle.

Locking Through

As you approach a lock, local regulations may require you to sound certain whistle signals indicating that you wish to be locked through. Your regulations may prohibit you from approaching closer than several hundred feet from the lock while waiting. Additionally, you may be required to maintain your position close to the bank to allow exiting vessels to use the center of the channel as they come out of the lock.

When all vessels have left the lock you will receive the lockmaster's signal to enter. This signal varies according to where you do your boating—it may be a series of lights or whistle signals or both. In any case, do not attempt to enter the lock until you have received permission to do so. When entering a lock, run at idle speed. A lock is no place to create a large wake. The lockmaster will direct you to the spot where he wants you to tie up inside the lock. Vessels are not permitted to drift around within the lock while the water level is being raised or lowered. All vessels must be moored.

You will be required to provide your own lines and they should be not only long enough but adequate for the task. These lines should be at least fifty feet long and longer if locking through some locks in the Tennessee Lakes system. The lockman will, in most cases, lower a line for the boat operator to pass up the eye of his mooring line. In some locks, both ends of the line must be retained on the boat and the bight of the line is sent up. After the line is secured by the lockman the operator can then control his boat. Boat operators and crewmen tending lock-mooring lines should always wear USCG approved personal flotation devices. Mooring lines should not be tied off on the boat. They must be carefully tended at all times. Extra care must be exercised during a downbound lockage that the mooring lines are not fouled when the water level in the lock is being lowered. A fouled line may result in a boat hanging up on the line and could cause serious damage or even capsize the boat. Use plenty of fenders to protect the hull from damage from rough or dirty lock walls.

Some locks have mooring pins in the lock walls. Others have floating bitts which raise and lower with the water level. In either case the lockman will direct you.

After all vessels are securely moored and the lock gates are closed, the lock is allowed to fill or empty. While being raised or lowered it will be necessary to take in line or pay it out as the case may be. All vessels must remain in their assigned positions until the lock gates are opened and the lockman gives the signal to depart. After the signal is given, all craft shall depart from the lock as directed by the lockman. As you leave the lock keep a sharp lookout for other craft approaching from the opposite direction.

That's all there is to locking through. If you are careful to observe all of your local regulations, maintain a slow speed when entering or leaving and follow the lockmaster's directions exactly, you will find that the pleasures of cruising our mighty rivers can be pleasantly extended for an endless number of miles in either direction.

Uniform State Waterway Marking System

Many bodies of water used by boatmen are located entirely within the boundaries of a state and are subject to regulation by the state. These waters do not connect to the sea. Since the concept of proceeding from seaward cannot be applied to these self-contained bodies of water, the lateral system of buoyage cannot be used. Thus, the individual states are left with no choice except to mark their waters with a different aids to navigation system.

The Uniform State Waterways Marking System has been devised for these lakes, ponds and rivers; and most states have adopted its use. However, some states deviate from this system to a certain extent in order to suit local conditions. Boatmen are well advised to determine in advance the aids to navigation system in use before embarking on these inland waters.

The Uniform State Waterways Marking System employs two categories of waterway markers—regulatory markers and aids to navigation.

Regulatory Markers

These consist of buoys and signs which indicate information pertaining to rules and regulations. All regulatory markers have white backgrounds and

orange borders. They may be circular, diamond or rectangular in shape. In most instances the nature of the danger or regulation is indicated in black letters or figures within the shape or adjacent to it.

6-10 A dangerous area is indicated by an open diamond shape, as shown below.

6-11 A prohibited area is marked by a diamond with a cross inside, as shown below.

6-12 A controlled area, such as one which excludes water skiing or fishing, is indicated by a circle, as shown below.

6-13 General information and directions are shown on a square or rectangular marker, as shown below.

Aids to Navigation

Aids to navigation on state waterways use red and black buoys to mark channel limits. Red and black buoys are generally used in pairs. The vessel should pass between the red buoy and its companion black buoy. These buoys will be found on opposite sides of the channel, with the red buoy on the left descending side and the black buoy on the right descending side of the river or stream.

Buoys that are not placed in pairs have distinctive colors which indicate the direction of the dangerous water from the position of the buoy.

VERTICAL RED AND WHITE STRIPED BUOYS indicate that vessels should not pass between the buoy and the nearest shore. Danger lies inshore of the buoy.

WHITE BUOYS WITH RED TOPS should be passed to the south or west. Do not go to the north or east of these buoys as danger lies to the north or east, as the case may be.

WHITE BUOYS WITH BLACK TOPS should be passed to the north or east. Do not go to the south or west of these buoys as danger lies to the south or west, as the case may be.

Identification of Markers and Aids to Navigation

Uniform State Waterway Marking System aids and markers may carry numbers, letters or words. Odd numbers are used on solid-black buoys and black-topped buoys. Even numbers are used on solid-red buoys and red-topped buoys. All numbers increase in an upstream direction, or toward the head of navigation.

Lighted buoys display regularly flashing, occulting or equal-interval light characteristics. Red lights are used on solid-red buoys; green lights are used on solid-black buoys; and white lights are used on all other buoys and regulatory markers.

Other Aids to Navigation

Lighthouses

Lighthouses are found on all coasts of the United States, on the Great Lakes, and along some of the interior waterways of the country. These structures are so well known that they require little description. Lighthouses are placed where they will be of most use, on prominent headlands, at entrances, on isolated dangers, or at other points where it is necessary that mariners be warned or guided. Their principal purpose is to support a light a considerable height above the water. The same structure may also house a fog signal and radiobeacon equipment, and also contain quarters for the keepers.

The terms, "secondary lights," "minor lights," and "automatic lights" indicate in a general way

6-14 Lighthouse

a wide variety of lights. These lights may be displayed from towers resembling the important seacoast lighthouses, or may be shown from almost any type of inexpensive structure. The number of lights with keepers in residence is gradually being reduced. The ultimate goal is to have all lights operate automatically, or nearly so. The essentials of lights where keepers are not in residence are: best possible location dependent on the physical conditions of the site, sufficient height for the location, a rugged support for the lantern, and a housing for the electric batteries from which the light is operated. Many types of structures meet these essentials—small tank houses surmounted by a short skeleton structure or tower, a cluster of piles supporting a battery box and the lens, and countless other forms.

Lights are used as a means of conveying certain definite information, and are given distinctive characteristics so that one light may be distinguished from another. This distinctiveness is obtained by employing lights of varying colors, by having lights that burn steadily, and others that flash at intervals of great variety.

By varying the length of the periods of light and darkness of any of the flashing or occulting characteristics, a great variety of characteristics may be

obtained. Advantage is taken of this to secure the necessary distinctiveness between aids of a given area.

Fog Signals

Fog signals form an important part of the equipment of many lighthouses situated in sections of the country where fog or low visibility is prevalent. Fog signals may also be found on floating aids to navigation. The function of the fog signal in the system of aids to navigation is to warn of danger, and to provide the mariner with a practical means of determining his position with relation to the fog signal at such times as the station or any visual signal which it displays is obscured from view by fog, snow, rain, smoke or thick weather. Among the devices in common use as fog signals are:

DIAPHONES, which produce sound by means of a slotted reciprocating piston actuated by compressed air. Blasts may consist of two tones of different pitch, in which case the first part of the blast is high and the last of a low pitch. These alternate pitch signals are called "two tone."

DIAPHRAGM HORNS, which produce sound by means of a diaphragm vibrated by compressed air, steam or electricity. Duplex or triplex horn units of differing pitch produce a chime signal.

SIRENS, which produce sound by means of either a disk or a cup-shaped rotor actuated by compressed air or by electricity.

WHISTLES, which produce sound by compressed air emitted through a circumferential slot into a cylindrical bell chamber.

BELLS, which are sounded by means of a hammer actuated by hand, by a descending weight, compressed gas or electricity.

Fog signals are distinguished by their characteristics as specified for each aid. The characteristic of a fog signal is described by its tone and signal characteristics. Its tone is determined by the device used to create the sound, such as diaphragm horn, diaphone, siren, bell or whistle. Fog signals on fixed stations or lightships produce a specific number of blasts and silent periods each minute, when operating, to provide positive identification. Fog signals on buoys are generally activated by the motion of the sea, and may emit no sound signals at all when the sea is calm. Fog signals at stations where a continuous watch is maintained are sounded when the visibility decreases to five miles, and also whenever the fog whistle of a passing vessel is heard. Fog signals at stations which also operate radiobeacons are synchronized with the radiobeacon for distance finding purposes (see Radiobeacons). Fog signals at locations where no continuous watch is maintained may not always be sounded promptly when fog conditions exist or may operate erratically due to mechanical difficulties.

Range Lights

Two lights, located some distance apart, visible usually in one direction only, are known as range lights. They are so located that the mariner, by bringing his vessel into line with them, when they will appear one over the other, places his vessel

6-15 Open Range — Not in Channel

6-16 Closed Range — in Channel

on the axis (or in the center line) of the channel. If he steers his vessel so that the lights remain constantly in line vertically, he will remain within the confines of the channel. Entrance channels are frequently marked by range lights. The Delaware River and the St. John's River on the Atlantic coast, and the Columbia River on the Pacific coast are examples of successive straight reaches marked in this manner. The lights of ranges may be any of the three standard colors, and may also be fixed, flashing or occulting; the principal requirement being that they stand out distinctly from their surroundings and from the background. Most range lights lose brilliance rapidly as the vessel moves off the channel center line.

Ranges should be used only after a careful examination of the chart. It is particularly important to determine the distance the range can be safely followed. This information is not obtainable from a visual inspection of the lights.

Lightships

Lightships serve the same purposes as lighthouses, being equipped with lights, fog signals and radiobeacons. They take the form of ships only because they are placed at points where it would be impracticable to build lighthouses. Lightships mark the entrances to important harbors and estuaries, dangerous shoals lying in much frequented water, and also serve as leading marks for both transoceanic and coastwise traffic.

6-17 Lightship

The masthead lights, the fog signals, and the radiobeacon signals of lightships all have definite characteristics, so that each lightship may be distinguished from the others and also from nearby lighthouses. As with lighthouses, details regarding these signals are shown briefly on charts and more completely in the light lists.

A lightship underway or off station will fly the International Code Signal flags "LO" signifying the lightship is not at anchor on her station. While underway (and not on station), the lightship will not show or sound any of the signals displayed or sounded while on station as a lightship, but will display the lights prescribed by the International or Inland Rules of the Road for a vessel of its class. While on station, a lightship shows the masthead light only, and a less brilliant light on the forestay, the latter serving to indicate the direction in which the ship is heading. By day, the lightship will display the International Code signal of the station, whenever it appears that an approaching vessel does not recognize the lightship or requests the information. As lightships ride to a single anchor, the light on the forestay also indicates the direction of the current. Lights on lightships are displayed from one hour before sunset until one hour after sunrise and at all times when the sound signal is in operation.

Relief lightships may be placed at any of the lightship stations and, when practicable, exhibit light, sound and radiobeacon signals having the same characteristics as the station. All lightships.

6-18 Off Shore Light Structure (Texas Tower)

except Lake Huron Lightship, are painted red with the name of the station in white on both sides. Lake Huron Lightship is painted black with the name of the station in white on both sides. Relief lightships are painted the same color as the regular station ships, with the word "RELIEF" in white letters on both sides.

When the Coast Guard's modernization program is complete, it is anticipated that offshore light stations (Texas tower type structures) will replace most lightships. Of the original 24, only Oregon's Columbia River and Washington State's Umatilla Reef Lightships will remain. They will maintain stations off the Pacific Northwest coast in positions where it would be impractical to build offshore stations.

Maritime Radiobeacons

Radiobeacons are valuable aids during fog and are also available for navigation in clear weather. In order to use this system, the mariner needs a radio direction finder, which is a specifically designed radio receiver with a directional antenna. This receiver is used to determine the direction of the signal being emitted by the shore station, relative to his vessel.

The basic value of the radiobeacon system lies in its simplicity of operation and its relatively low cost even though the results obtained may be somewhat limited. The general problems and practices of navigation when using radiobeacons are very similar to those encountered when using visual bearings of lighthouses or other charted objects.

Most United States and Canadian radiobeacons must share a group frequency with other radiobeacons. Normally, the stations operate in groups of six, each station in a group using the same frequency and transmitting for one minute in its proper sequence. A few radiobeacons transmit for one minute with two minutes of silence, and some radiobeacons transmit continuously without interruption.

Radiobeacons operate during all periods, either sequenced or continuously, regardless of weather conditions.

For station identification, simple characteristics consisting of combinations of dots and dashes are used. These combinations, and the lengths of the dots, dashes and spaces are chosen for ease of identification. It is not necessary to be skilled in the art of radiotelegraphy to identify the stations. The combinations are not transmitted as Morse Code and are not referred to as such.

They are referred to by dots and dashes depending on the combinations used. For example, Cape Henlopen's characteristic is . . — . . and Portland's is — — . — —. All radiobeacons superimpose the characteristic on a carrier which is "on" continuously during the period of transmission. This extends the usefulness of the marine radiobeacons to aircraft and vessels which employ automatic radio direction finders.

The service range is determined by the strength of the radiated signal. The actual useful range may vary considerably from the service range with different types of radio direction finders and during various atmospheric conditions.

The accuracy of radiodirection finders is dependent upon the skill of the operator, the equipment used, and the radio wave interference. Skill in using a manually operated radio direction finder can be acquired only through practice and by following exactly the operating instructions provided with the equipment. An understanding of adverse conditions and direction finding limitations must be achieved before the navigator can use the equipment with confidence.

As an operator obtains bearings with a manually revolving loop type direction finder, he can estimate the bearing by the arc of silence (null) or minimum strength of the radiated signal. He should, however, be cognizant of the possibility of errors and should evaluate the circumstances under which the bearing was taken. Bearings taken on inland stations could contain error due to refraction or reflection, and such bearings should be used cautiously. Bearings taken around the periods of morning and evening twilight should be considered of doubtful validity due to "night effect." Erroneous readings could be caused by currents induced in the direction finder antenna by re-radiation from structural features aboard the vessel, such as masts, davits, radio antennas and other vertical metallic objects. Lateral deviation of the radio wave can occur when the great circle route between the

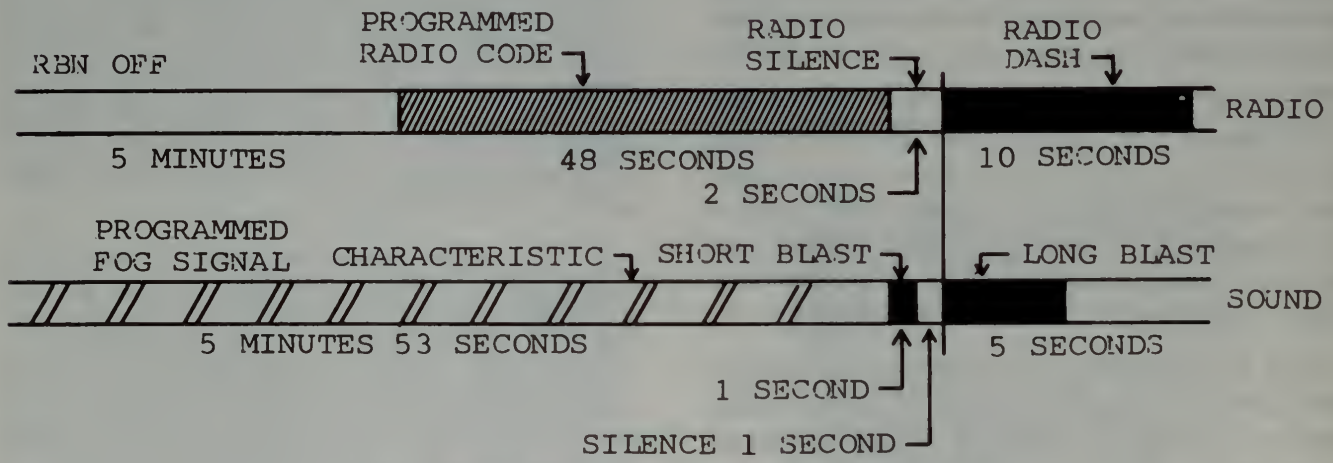
transmitter and the receiver is roughly parallel to a coastline. Also, bearings taken when a land mass is between the transmitter and the receiver should be used with caution. Whenever possible, the mariner should check his radio bearings against visual sightings in clear weather to determine the degree of accuracy that is to be expected in periods of reduced visibility.

Distance-Finding Stations

At certain stations, the radiobeacon and sound signal are synchronized for distance finding. The beginning of the ten-second radio dash and the beginning of the five-second blast of the fog signal are synchronized for this purpose. The ten-second radio dash and the long (5 second) blast of the fog signal commence at the same instant. Therefore, when within audible range of the sound signal, navigators on vessels with radio receivers capable of receiving radiobeacon signals may readily determine their distance from the station by observing the time in seconds which elapsed between first hearing the beginning of the ten-second radio dash and the beginning of the five-second sound blast. The time in seconds is divided by 5.5 to determine the distance off from the station emitting the signals in nautical miles. The accuracy of this type of calculation, provided the stop watch is correctly read, would be within a tolerance of about 10 per cent.

The two-seconds of silence preceding the long radio dash is a stand-by or warning signal. The one-second fog signal blast is also a warning. It is important to point out that the distance finding system just described is not restricted to vessels having radio direction finding equipment aboard, but may be used by any vessel having a radio receiver capable of receiving on the 285 to 325 KHz band.

An example of a typical synchronized radio-sound system follows:



6-19 Typical Synchronized Radio-Sound System.

If the interval between hearing the beginning of the long radio dash marking the end of the radiobeacon minute and the beginning of the long blast of the fog signal is 33 seconds, the observer is 33 ÷ 5.5 = 6 miles from the station.

Marker Radiobeacons

Marker radiobeacons are of low power for local use only, and are seldom heard at a distance of more than four or five miles from the station. They operate continuously, transmitting a series of ½ second dashes for 13½ seconds, followed by a 1½ second silent period to complete a fifteen-second cycle.

Loran

The term "LORAN" is derived by combining the first letters of the words "LOng Range Aid to Navigation." LORAN is an electronic system by which a navigator can determine his position

or a line of position accurately and quickly, unaffected by weather. It makes use of special radio transmitting stations on shore (LORAN transmitting stations), specially designed radio receivers with an electronic time-measuring device (LORAN receiving indicator), and special charts and tables (LORAN charts and tables).

The LORAN transmitting stations, critically spaced on shore, operate in pairs. Each produces signals from which one line of position may be determined. Pairs are further arranged in chains of three or more stations from which two or more lines of position can be derived, thereby providing fix coverage. When the chain arrangement is used, the intermediate station operates in both adjacent pairs. The navigator may obtain position information from any pair, both stations of which are within reception range of his receiver-indicator.

Ocean Station Vessels

With the exception of large ocean-going yachts, ocean station vessels (on station) will seldom, if ever, be seen by pleasure boatmen. However, they do represent an integral part of the aids to navigation system and a few words concerning these ocean station vessels might be of interest.

Called by some, "Weather Station," or "Weather Patrol," an ocean station is a selected section of the ocean 210 miles square, located hundreds of miles from the nearest land in both the North Atlantic and North Pacific Oceans. Except for emergencies, the ocean station vessel stays in the ten mile square center grid. This is not as easy as it sounds. The ship is continually moving within that square, drifting from one side to the other. Then it must get underway and return to the original starting point, to begin the process all over again. It is impossible to anchor in the deep water and the drifting method saves fuel.

Acting as an aid to navigation and supplying weather information are two essential functions of ocean station vessels. Compared to the history of seafaring, both functions are relatively new. There is no historical evidence to indicate that early mariners ever thought of instituting an aid to navigation such as the ocean station. Today, increased navigational capabilities aboard modern aircraft, as well as the expanding coverage of reliable electronic navigation systems, have alleviated much of the need for Ocean Stations as a navigational reference point. The meteorological function of this program is slowly being taken over by large automated weather data collection buoys for surface observations as well as the present weather satellite system.

6-20 Loran Transmitting Station

6-21 Weather Buoy

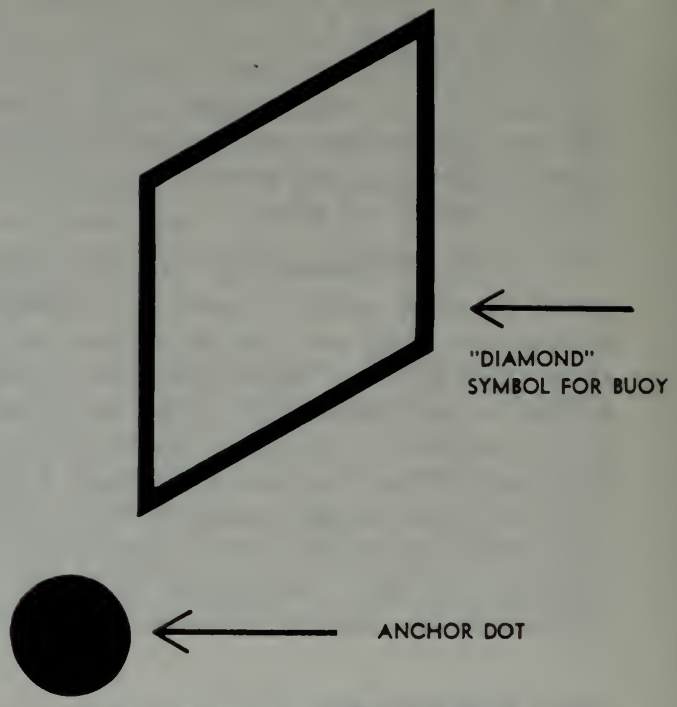
Chart Symbols for Aids to Navigation

All aids to navigation are depicted on charts by the use of symbols. These symbols make no attempt at accuracy in scale or detail. Chart No. 1, published in booklet form, lists each symbol in use on charts issued by the U.S. Lake Survey, National Ocean Survey (NOS) and the U.S. Navy Oceanographic Office. The student is well advised to procure a copy of this booklet and become familiar with the symbols for the more commonly used aids to navigation, and marine hazards relative to the operation of small craft.

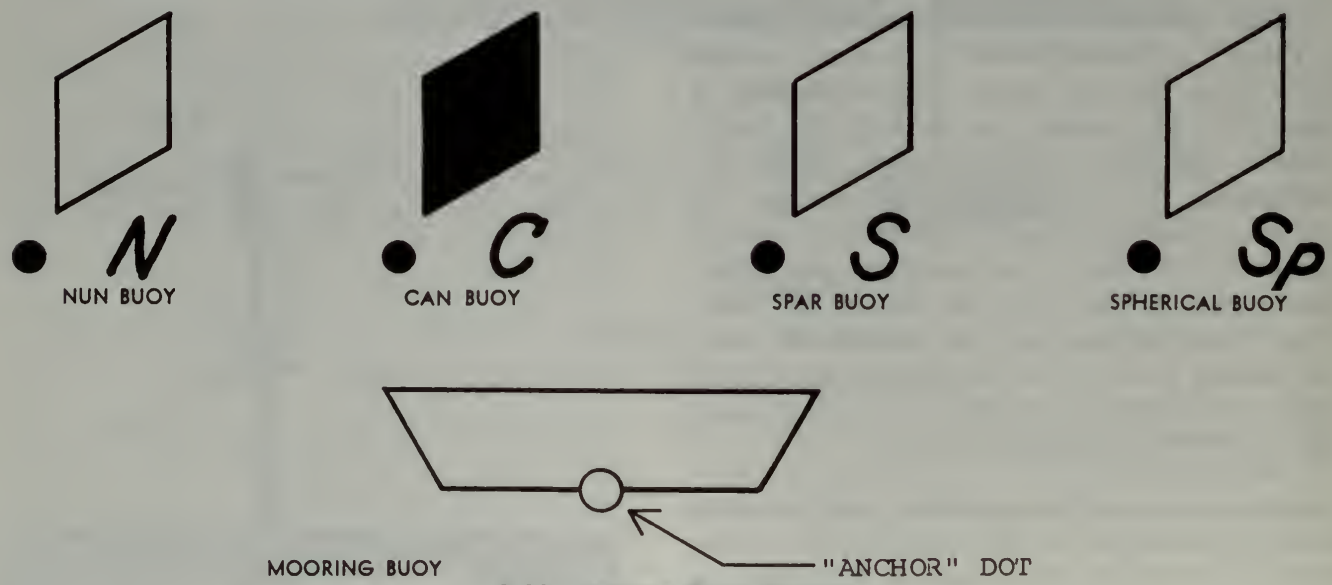
Symbols for Buoys

The basic symbol for a buoy is a diamond and a dot. The dot denotes the position of the buoy and is sometimes called the anchor dot. The diamond is used primarily to draw attention to the position of the anchor dot, and it also may partially describe the aid in question.

The position of the diamond with reference to the dot is of no significance. The diamond may be placed in any attitude relative to the dot, to suit the situation and to afford the least amount of interference with other local features or conditions on the chart. (If the diamond is below the dot on the chart, it does not mean that the buoy is upside down!)



6-22 Basic Symbol For a Buoy



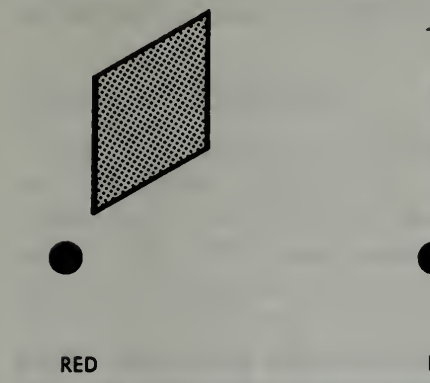
6-23 Various Buoy Symbols

The shape of the buoy will be indicated by initials if the shape is of significance.

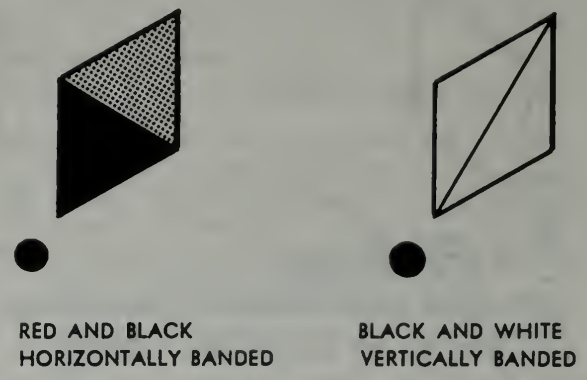
A mooring buoy is the only buoy that is depicted by a symbol other than the diamond and dot. This symbol is a quadrangle with the anchor dot at the bottom

If the aid is painted red, the diamond will generally be colored red; and if the aid is painted black,

the diamond will be black. If the aid is red and black horizontally banded, the diamond will be red and black. If the aid is white and black vertically striped, the diamond will have a line drawn through its long dimension.



6-24 Red and Black Buoy Symbols



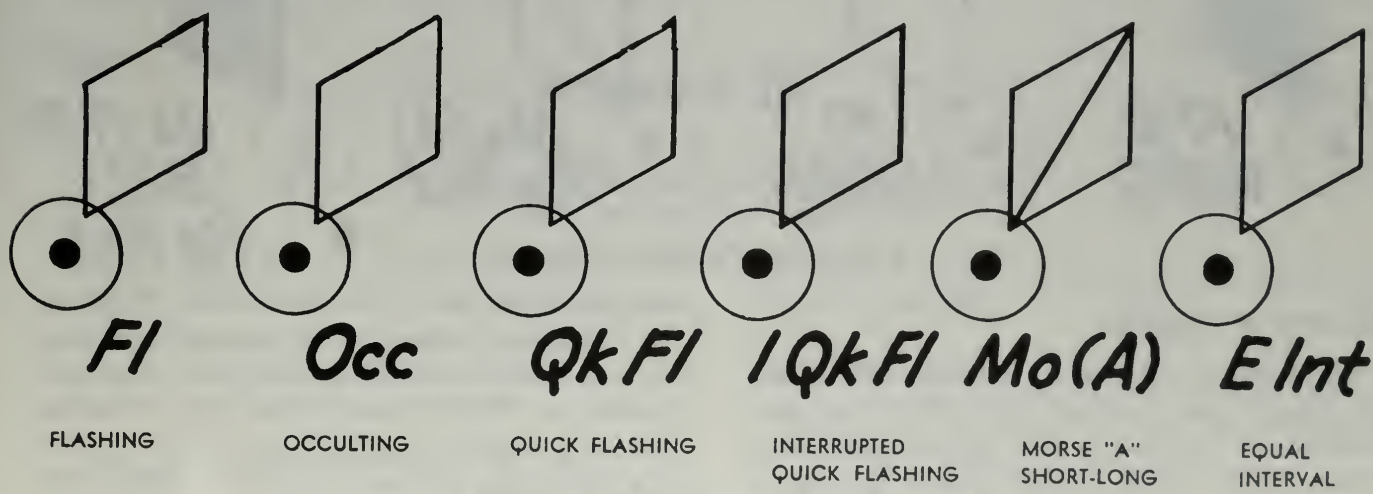
6-25 Banded Buoy Symbols

The five color patterns used on buoys which have no lateral significance are shown as follows:

(In each case below, the buoy is cylindrical in shape.)

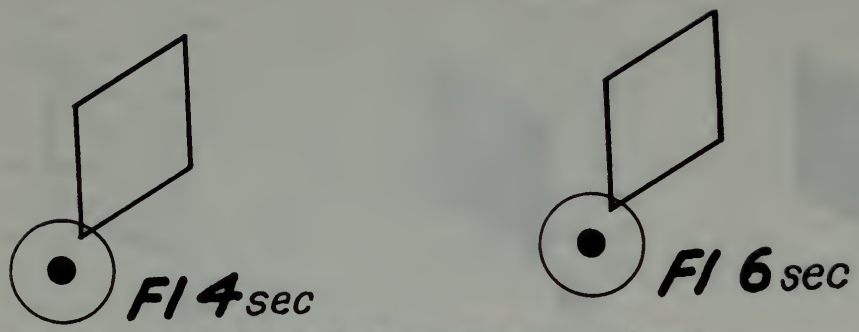
6-26 Buoys with No Lateral Significance

If a buoy is lighted, a magenta colored disc will be overprinted on the anchor dot. The characteristic of the light will be described briefly. This is done by the use of abbreviations. These are as follows:



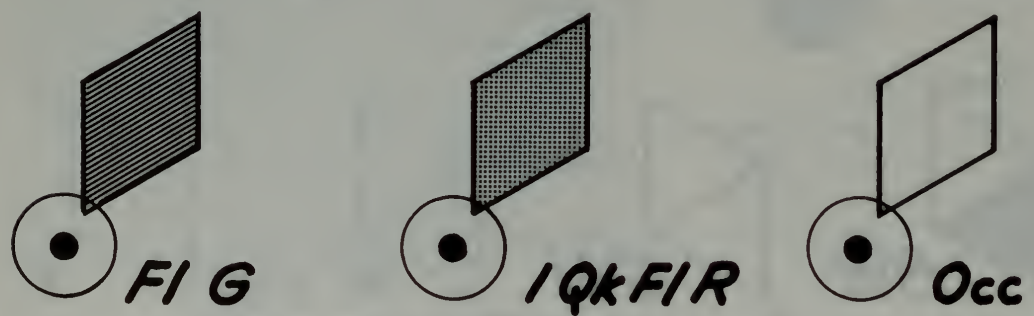
6-27 Example of Lighted Buoy Symbols

Flashing lights may be further identified according to their timed characteristics.



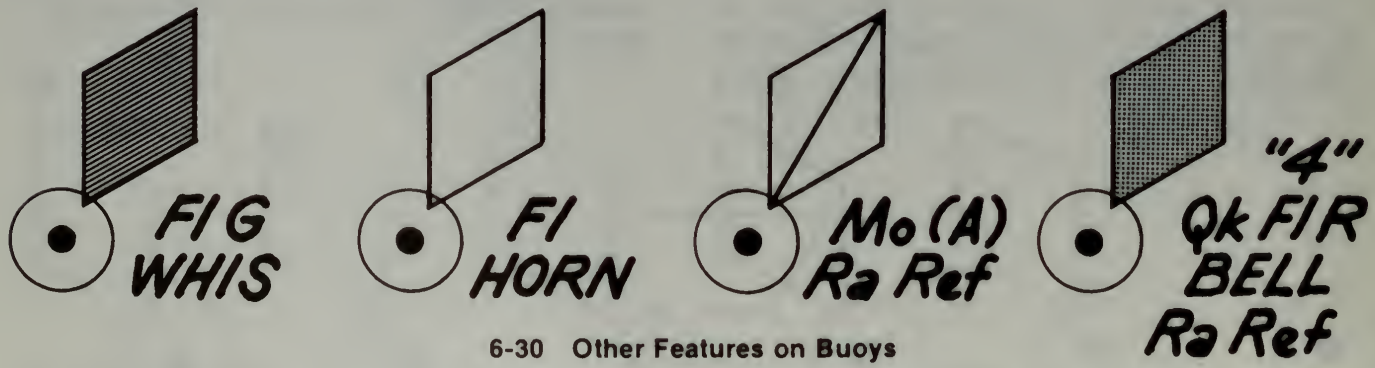
6-28 Time Characteristics of Flashing Light Buoys

The color of the light is also indicated on the chart. Colors of lights on buoys are either red, green or white. For red or green lights, the initials R or G are used. If the color of the light is not identified on the chart, it is assumed that the light is white.



6-29 Colored Lights on Buoys

Other features may also be on the buoy. These are sound signals, radar reflectors, numbers or letters, or any combination of these features. Bells and horns are spelled out; radar reflectors are abbreviated; and numbers or letters which are painted on the aid are shown in quotation marks.



6-30 Other Features on Buoys

The Rule of Lettering

On all charts, lettering is printed in both vertical and slanted type. The basic rule is that if an object is afloat, or if it covers and uncovers with tidal action of the water, the descriptive wording or abbreviation is printed in *SLANTED TYPE*. If the object is not afloat, or if it does not cover and uncover with the tide, the descriptive wording is printed in VERTICAL TYPE. Thus a mariner can tell at a glance if ALPHA ROCK is an islet or a reef. If the wording is printed in slanted type,

it can at times be under water and thus may not be seen. All descriptive lettering for floating aids to navigation is found in slanted type, while descriptions of lighthouses, ranges and other objects not afloat are found in vertical type.

Symbols for Lighthouses

The basic symbol for a lighthouse is a dot with an overprinted magenta disc. Major lights are named and described while minor lights are described only. The characteristics of the light are shown; the height of the focal plane of the lantern above mean high water is also shown. The geographic or nominal range is shown (approximately) in miles, and other equipment on the station is listed.

The symbol shown below describes a minor light (not named). The light is fixed white and the lantern is 20 feet above mean high water and visible nine miles. (Height of eye of the observer is assumed to be 15 feet above mean sea level.)

FW
20 FT 9 M
SYMBOL FOR A MINOR LIGHT.

If the lighthouse has a radiobeacon, the magenta disc is surrounded by a magenta circle and the radio frequency and identifying signal are described.

The lighthouse depicted below is described as follows:

SILVER REEF LIGHT
Displays a group of two flashes of white light every 10 seconds.
The lantern is 87 feet above MHW and is visible through its geographic range (10.5 miles + 4.4 miles for the assumed height of eye of the observer of 15 feet).
This station has a fog horn and a distance finding system. (Synchronized radio-sound signal)
The radiobeacon is on continuously, on frequency 292 kHz and is identified by a dot, a dash and two dots.

If the radiobeacon shared a frequency with other stations, the sequence within the group would be indicated by a Roman Numeral. Each station is assigned a minute in its proper sequence. If this station were fourth in its group, the Roman Numeral IV would appear behind the RBN frequency. (Normally, the stations operate in groups of six.)

SILVER REEF
GP FL (2) 10 SEC 87 FT 15 M
HORN DFS
R Bn 292 ●▬●● CONTINUOUSLY

R BN 292 ●▬●● IV

IF THIS RADIOBEACON WERE FOURTH IN ITS GROUP THE ROMAN NUMERAL IV WOULD APPEAR AS SHOWN ABOVE

6-31 Symbols for Lighthouses

Certain lights are not visible through the 360° arc of the horizon, because of interference by land masses. When a light is observed through a portion of its arc, the symbol for the light on the chart is shown with an obscured sector.

Some lights contain a red sector to warn of special dangers within the arc of visibility of the sector. When a light contains such a sector, it is shown on the chart.

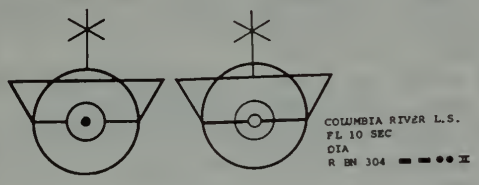
Symbols for Lightships

Symbols for lightships include a brief description of the vessel's signaling capabilities.

Columbia River Lightship has a diaphone and

Radiobeacon in addition to the light. The Radiobeacon shares frequency 304 KHz with five other lights in the vicinity, and is second in the regular sequence of six one-minute transmissions.

This sequence, which is typical of the shared sequence system, is as follows:

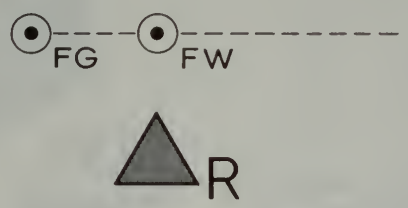


6-32 Symbols for Lightships

Minute		
I	Cape Arago Lt	— • — —
II	Columbia River LS	— — • •
III	Willapa Bay Lt	• • — —
IV	Cape Disappointment Lt	— — —
V	Cape Blanco Lt	— — — •
VI	Yaquina Head Lt	• — —
	All on frequency 304 KHz	

Symbols for Ranges and Daybeacons

Ranges are depicted on charts by the symbols for the lights (if lighted) and a dashed line indicating the direction of the range.



6-33 Symbols for Ranges and Daybeacons

Since the far light is higher than the near light, this range is followed by keeping the fixed green light directly above the fixed white light.

Daybeacons are depicted by small triangles, sometimes colored to match the aid itself. Beacons are never afloat, and have a great array of shapes. They are described in sufficient detail in the Light List to make identification possible.

Distance of Visibility at Sea

This chapter on Aids to Navigation would not be complete without some comment concerning the distance of visibility of objects at sea.

Distance of visibility is dependent on many factors. For all objects, atmospheric conditions become the first limiting factor. Dense fog could reduce the visible distance to zero. The height of the object increases the distance from which it can be seen. Similarly, if one increases the height of the eye, objects may be seen at a greater distance. Thus height of the object and height of eye become the second limiting factor. On lighthouses (and other lighted aids) the intensity of the light becomes the third limiting factor. Regardless of how high a light is placed above water level, it will not be seen as far away in the case of a weak light as it would be if it were a more powerful light.

Atmospheric Conditions

When listening to weather reports before putting out to sea, one often hears terms such as "thick fog" or "haze." These terms are not mere generalities, but are determined according to values which have been agreed upon by all maritime nations and are listed in the "International Visibility Code." A part of the table of *Meteorological Optical Range* is reproduced below. By reference to this table, the navigator may determine the approximate distance from which objects (headlands, breakwaters, etc.) may be expected to be seen in the circumstances.

METEOROLOGICAL OPTICAL RANGE

Code No.	*Weather*	*Statute Miles*	*Yards*
0	Dense Fog	0.0 to 0.03	0 to 50
1	Thick Fog	0.03 to 0.12	50 to 200
3	Moderate Fog	0.12 to 0.31	200 to 500
3	Light Fog	0.31 to 0.62	500 to 1,000
			Nautical Miles
4	Thin Fog	0.62 to 1.2	0.5 to 1.0
5	Haze	1.2 to 2.5	1.0 to 2.0
6	Light Haze	2.5 to 6.2	2.0 to 5.5
7	Clear	6.2 to 12.0	5.5 to 11.0
8	Very Clear	12.0 to 31.0	11.0 to 27.0
9	Exceptionally Clear	over 31.0	over 27.0

NOTE: On Coastal Waters, the Nautical Mile is

employed. On the Great Lakes (and on all inland waters) the Statute Mile is used.

Nominal Range

Nominal Range is the maximum distance at which a light may be seen in clear weather (Visibility Code 7 above) expressed in nautical miles on coastal waters and statute miles on the Great Lakes. Nominal range is listed in the Light List for lights having a computed nominal range of five nautical miles (or statute miles) or more.

Luminous Range

Luminous range is the maximum distance at which a light may be seen under existing visibility conditions. The luminous range varies considerably with atmospheric conditions and the intensity of the light. The luminous range may be determined by Luminous Range Diagrams included in the various Light Lists published by the Coast Guard. The student is referred to these publications for further study, if interested.

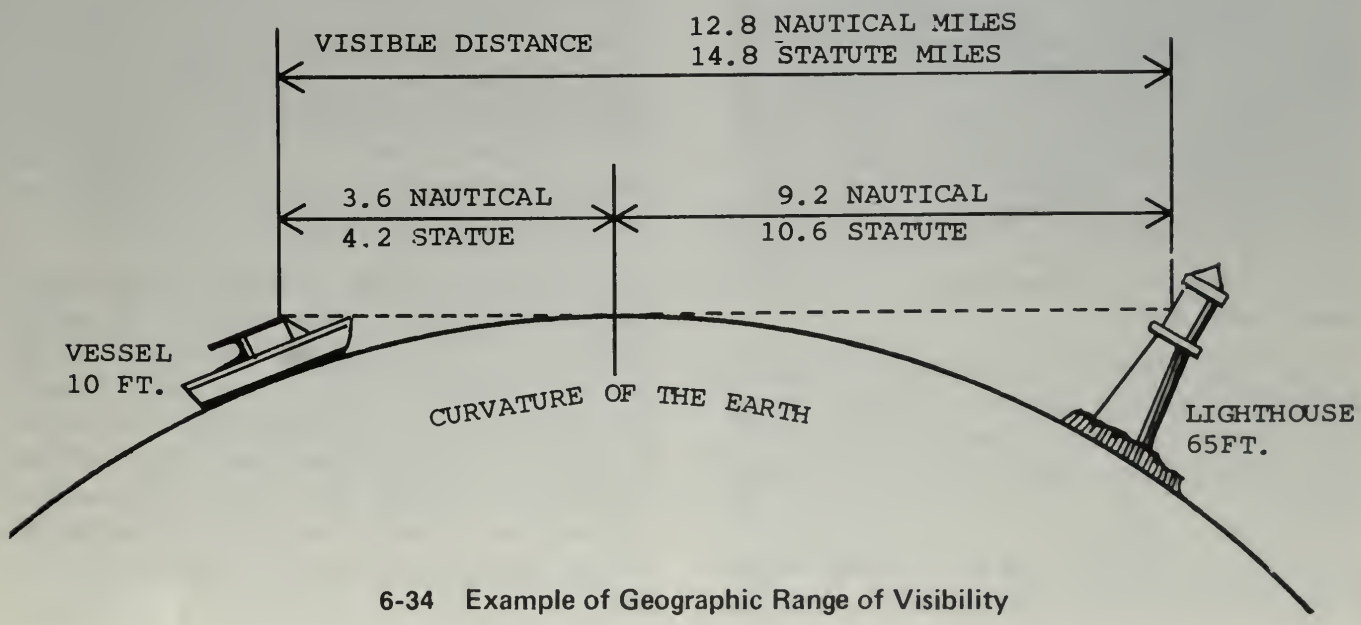
Geographic Range

Geographic range is the maximum distance at which a light may be seen under conditions of perfect visibility, limited by the curvature of the earth only. This is expressed in nautical miles for coastal waters and in statute miles for the Great Lakes. This distance may be found on some charts with a brief description of the light, and assumes the eye of the observer to be at a height of fifteen feet above sea (or lake) level. In cases of lights with moderate candlepower, the nominal range (again in conditions of perfect visibility) may be shown on the charts in place of the geographic range. The National Ocean Survey will chart only the nominal range of all lights.

The following tables give the approximate geographic range of visibility of an object which may be seen by an observer whose eye is at sea level. In practice, it is necessary to add to these a distance of visibility corresponding to the height of the observer's eye above sea level.

DISTANCE OF VISIBILITY OF OBJECTS AT SEA
COASTAL WATERS
(Nautical Miles)

Height (feet)	Distance (nautical miles)	Height (feet)	Distance (nautical miles)	Height (feet)	Distance (nautical miles)
5	2.6	70	9.6	250	18.1
10	3.6	75	9.9	300	19.8
15	4.4	80	10.2	350	21.4
20	5.1	85	10.5	400	22.9
25	5.7	90	10.9	450	24.3
30	6.3	95	11.2	500	25.6
35	6.8	100	11.4	550	26.8
40	7.2	110	12.0	600	28.0
45	7.7	120	12.5	650	29.1
50	8.1	130	13.0	700	30.3
55	8.5	140	11.5	800	32.4
60	8.9	150	14.0	900	34.3
65	9.2	200	16.2	1,000	36.2



6-34 Example of Geographic Range of Visibility

GREAT LAKES
(Statute Miles)

Height (feet)	Distance (statute miles)	Height (feet)	Distance (statute miles)	Height (feet)	Distance (statute miles)
5	2.9	70	11.0	250	20.9
10	4.2	75	11.4	300	22.9
15	5.1	80	11.8	350	24.7
20	5.9	85	12.2	400	26.4
25	6.6	90	12.5	450	28.0
30	7.2	95	12.9	500	29.5
35	7.8	100	13.2	550	31.0
40	8.3	110	13.8	600	32.3
45	8.9	120	14.5	650	33.6
50	9.3	130	15.1	700	34.7
55	9.8	140	15.6	800	37.3
60	10.2	150	16.2	900	39.6
65	10.6	200	18.7	1,000	41.7

Useful Navigational Publications

Light Lists

In order to keep mariners informed concerning the status of various aids to navigation, which change almost daily, the Coast Guard and the Navy Oceanographic Office issue certain informative publications. One series is the *Coast Guard Light Lists*, which are complete compilations of all aids to navigation maintained by the Coast Guard, geographically listed. The Light Lists give supplementary information on aids to navigation which cannot be included on the charts. Copies of the Light Lists are available from the Superintendent of Documents, Government Printing Office, Washington, D.C., 20402, at a nominal fee, and from local sales agents, who are listed annually in the *Weekly Notice to Mariners*.

The following Lists are available:

Light List, Atlantic Coast, Volume I (CG-158) describing aids to navigation in the United States waters from St. Croix River, Maine, to Little River, South Carolina.

Light List, Atlantic and Gulf Coast, Volume II (CG-160) describing aids to navigation in the United States waters from Little River, South Carolina, to Rio Grande River, Texas, and the Greater Antilles.

Light List, Pacific Coast and Pacific Islands, Volume III (CG-162) describing aids to navigation in United States waters off the Pacific Coast and outlying Pacific Islands. For the convenience of mariners, there are included also the lighted aids on the coast of British Columbia, maintained by the Canadian government.

Light List, Great Lakes, Volume IV (CG-157) describing aids to navigation maintained by the United States Coast Guard, and the lighted side maintained by the Dominion of Canada on the Great Lakes and the St. Lawrence River, above the St. Regis River.

Light List, Mississippi River System, Volume V (CG-161) describing the aids to navigation on the Mississippi and Ohio Rivers and navigable tributaries.

Notice to Mariners

The *Notice to Mariners* announces items of importance to the safety of marine navigation concerning aids to navigation, channel conditions, menaces to navigation and all special conditions of interest to mariners. There are three methods by which this information is disseminated—Broadcast Notices, Local Notices and Weekly Notices. Urgent notices concerning changes or deficiencies in aids to navigation are issued by means of radio broadcasts. *Local Notices to Mariners* are issued by the Commanders of the applicable Coast Guard Districts. Weekly notices to mariners, published jointly by the Coast Guard and the Naval Oceanographic Office, contain information on aids to navigation over much wider areas than the Local Notices, and are used principally to correct charts and other nautical publications.

The Local Notices are valuable to the boatmen as a navigational aid to local waters, and may be obtained free of charge by application to the Commander of the Coast Guard District in which the boat is principally operated. Weekly Notices are intended for seagoing vessels and others requiring information covering wide areas. They may be obtained free of charge from the Commandant (G-WAN), U.S. Coast Guard, Washington, D.C. 20590.

CHAPTER 7

Charts and Compass

The Marine Compass

A compass is an absolute necessity if you are planning on offshore sailing. A good pocket compass is better than none. While cost may be the governing factor in the selection of compass, preferably it should be one that fits the individual boat, and upon which the operator may rely totally.

A compass that is too small has a tendency to be nervous and overact to the motion of the boat; also it is harder to read a small compass accurately. On the other hand a too-large compass will lag behind the ability of a small boat to swing, and will respond sluggishly to a change of helm.

In very general terms, a 2 inch or 2½ inch diameter compass card would be suitable for most boats less than 26 feet in length. The very popular 3½ inch diameter compass card would be ideal for boats in the 23 to 26 foot range and is adequate for most boats up to about 35 feet. The 4 and 5 inch diameter compass, however, begins to be very popular when the boat length gets up to 35 to 40 feet. For boats 40 to 65 feet in length a 6 or 7 inch model would be desirable.

As in any precision instrument, price determines the refinements which can be included. Desirable features would include: built in compensators to correct for deviation (errors caused by metallic objects built into the boat), proper illumination (this should be a red light), internal gimbaling (pivoting devices which allow the card to remain horizontal regardless of the angle of the body or boat), and an expansion chamber to keep the compass bubble free.

Certain questions should be considered prior to final selection and purchase. Your selection will depend to a great extent on where you can mount your compass. Some marine compasses are "front reading" like an automobile compass, while others are read "over the top of the card." A compass that reads directly over the card is usually preferred whenever it is possible to mount this type of instrument.

7-1 Front Reading Compass

One important point should be brought out now. In mounting your compass it is not necessary to set it over the fore-and-aft centerline (keel) of the boat. It must, however, be set so that an imaginary line through the lubber's line and the extension pin over the pivot point will be parallel with the keel. The lubber's line is the marking on the case or bowl of the compass. You steer by turning the

vessel so that the desired compass course is opposite this mark. Remember, the compass card tends always to remain with the north point turned towards the Magnetic North Pole and you maintain your desired compass heading by turning the boat about the pivot point of the compass.

7-2 Over the Card Reading Compass

Compass Construction

Just what does comprise a good modern marine compass? The compass card, usually with either two or five degree graduations, pivots on a jeweled bearing. The pivot point is a hard alloy. An alloy magnet or, in some models, a bundle of needle magnets, is mounted on the underside of the card and is aligned with the north-south marking. The card and the pivot may be mounted on internal gimbals to allow for maximum heeling in sailing craft. Most compasses are now in spherical containers. The best are truly spherical so that as the card tilts the liquid displacement is uniform on both sides of the card for the most effective dampening action.

Internal compensation magnets will correct a modest amount of deviation error and beyond that you can always add external rod magnets in small tubular brass holders if your deviation is excessive. Your compass will be filled with a suitable compass fluid. This fluid serves the dual purposes of dampening card oscillations and of reducing bearing pressures by partly floating the compass card.

This is a good place for a warning—do not try to refill your compass with kerosene if a bubble develops. The wrong fluid may very well react with the plastic bowl and ruin it. If your compass has developed a bubble, it is highly probable that the diaphragm of the pressure compensating chamber has a pinhole and will have to be replaced. You will not have this spare part in your tool box anyway. If the compass is an inexpensive one, plan to replace it. If it is an expensive instrument, there are service stations where repairs can be made but their services are expensive.

Using Our Compass

We have our boat and a compass, but what now? Well, in the most elementary terms, if we leave the harbor heading down channel and our compass reads 110 degrees, then, should it get foggy on the way back, we should arrive home safely by heading on a compass course of 110° plus 180° or 290° coming up-channel. For the sake of simplicity we have assumed our compass has no deviation error in this instance. Most other usage of a compass is not really much more complicated than this once we learn to handle the so-called "errors."

Compass Errors

We have mentioned deviation error previously. There are several natural phenomena which will cause a compass needle to be deflected so that it does not point in a true north direction. These are called compass errors. Actually they are not compass defects but are simply magnetic influences of one kind or another which affect the direction in which the compass points. There are only two of these that we will concern ourselves within this text—variation and deviation. An unusual error called "local attraction" is a local magnetic disturbance of sufficient force to cause a noticable deflection of a magnetic compass. This is noted on the chart of the area. If you have com-

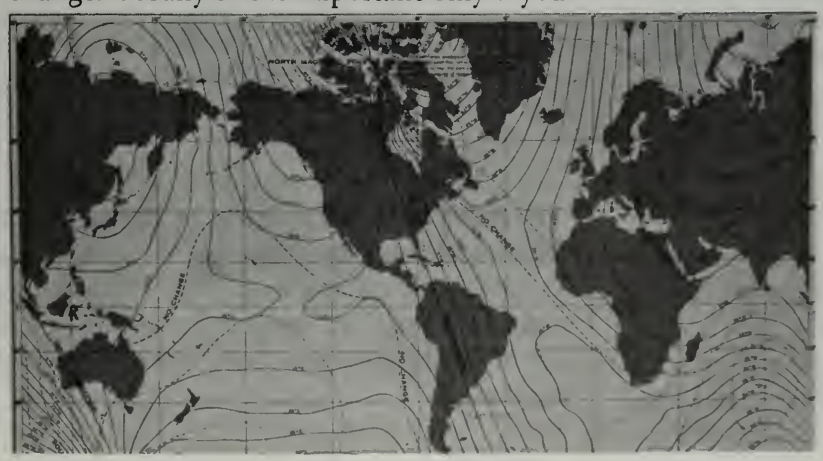
pass problems due to boat construction (steel hulls), or heeling error (cruising sailing craft), more advanced texts should be consulted for guidance.

Variation

We will consider variation first because it applies to all compasses and almost all areas. Variation is defined as the angular difference expressed in degrees between the direction toward true north (North Pole) and the direction toward magnetic north (compass north). This difference is expressed as either an easterly or a westerly "error." This obviously needs some additional explanation.

The masses of magnetic ore that form the North and South Magnetic Poles are not at the geographic poles. Neither are they 180 degrees opposite each other. Therefore the magnetic field they create around the earth is somewhat distorted, and the compass needle varies in the direction it points, depending on our location relative to this distorted field and the true poles.

Variation is labeled E (east) or W (west). This describes the direction the magnetic needle moves from true north. Most of the East Coast and Great Lakes have westerly variation, while the West Coast and the Gulf of Mexico have easterly variation. Variation is always the same for all boats in one location; it does not vary from boat to boat. Local variation is shown several times on charts. Look for this information in the center of the compass roses on your charts. In some areas the variation changes slightly from year to year and your chart may indicate a few minutes of annual change. Usually this is important only if you are working from a very old and out-of-date chart, which is dangerous practice if a more current chart can be obtained. For practical piloting, we will convert the variation as given to the nearest whole degree and use this figure to make our corrections. Thus, a variation given as 11°40'W in 1958, with an annual change of 2'W would be updated and rounded off to the nearest full degree—12°W.



7-3 World Chart of Isogonic Lines (Line—Connecting Points of Equal Variation).

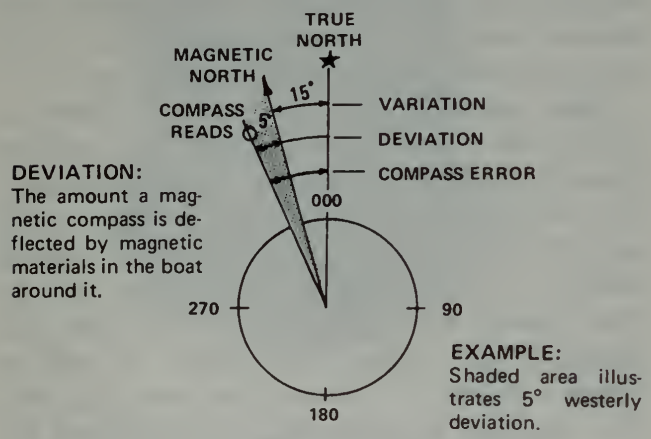
Deviation

A wooden sailing vessel with no engine would probably have very little if any deviation error. Add an engine and several items of electronic navigation equipment near the helm and compass and this same vessel will have compass deviation errors. This requires either compensation of the compass to remove all error or the correction of compass courses to give consideration to these deviation errors.

Simply stated, deviation is the angular difference between the magnetic course of the vessel and the course indicated on the compass (compass course). This error is not necessarily a constant for a vessel but will change with each change in the boat's heading. As with variation, this error can be either easterly or westerly. A boat's deviation can change if you change the engines, or add or subtract wiring or electronic gear near the compass. Methods of determining deviation and the compensation of compasses to reduce the error will not be covered in this text. You will learn how to handle it when you are more aware of its magnitude. Other texts and more advanced courses will offer an opportunity to learn how to determine your deviation and compensate your compass to reduce the deviation, and how to prepare a deviation table to handle any remaining error, which is usually not more than 3 to 5 degrees.

There are many professional compass correctors located in boating areas, who for a small fee, will compensate your compass and make up a deviation table for you. This is money well spent.

It would seem appropriate at this point to offer a word of cheer to our many outboard motorboat operators. Your engine is at the stern, usually as far from the helm as possible, and it is largely composed of aluminum parts which are nonmagnetic. It is most probable that you do not have enough deviation error to worry about. This is especially true since it is also a practical fact that except in a flat calm you probably cannot steer closer than three to five degrees of your intended course. For you, this means the magnetic course is also your compass or steering course, and piloting becomes just that much simpler. In the event that you should "graduate" to a larger boat, as many of us do, learn about deviation anyway. You will not regret it.



7-4 Illustration of Deviation

DEVIATION TABLE

(A TABULATION OF THE DEVIATIONS ON VARIOUS HEADINGS)

SHIPS HEAD COMPASS	TRUE BEARING OF RANGE	VARIATION	MAGNETIC BEARING OF RANGE	COMPASS BEARING OF RANGE	DEVIATION
000°	061°	2°W	063°	058°	5°E
015°	061°	2°W	063°	060°	3°E
030°	061°	2°W	063°	061°	2°E
045°	061°	2°W	063°	062°	1°E
060°	061°	2°W	063°	062°	1°E
075°	061°	2°W	063°	064°	1°W

If your compass heading is 75°
What is your magnetic heading?

7-5 Deviation Table

Handling Compass Errors

We have discussed the two primary errors in some detail. Now it is necessary to learn how to handle these errors to determine the proper compass course, and conversely to determine the true course from a compass course or a true bearing from a compass bearing.

Westerly errors, either variation or deviation, are added as we go from true course to compass course, and easterly errors are therefore subtracted. Conversely, converting from compass course or bearing to a true course or bearing, westerly errors would be subtracted and easterly errors would be added. An easy way to remember this is to memorize the phrase:

*T*rue *V*irtue *M*akes *D*ull Company—Add Whiskey

From this you get:

T	V	M	D	C
(True)	(Variation)	(Magnetic)	(Deviation	(Compass)
	A		(W)	
	(Add)		(Westerly)	

The complete formula is:

+West
−East

T V M D C

−West
+East

In going from true course or magnetic course to compass course, you add westerly variation and/or deviation and subtract easterly. When going from compass course to magnetic or true course you subtract westerly and add easterly deviation or variation.

It is often a good idea to write this formula down when you are going to use it. Let's take an example:

assume the true course from your present position to a desired destination is 095°, and the variation is 14°40'E. Then write out the formula and known error as follows:

T	V	M	D	C
095	15E			

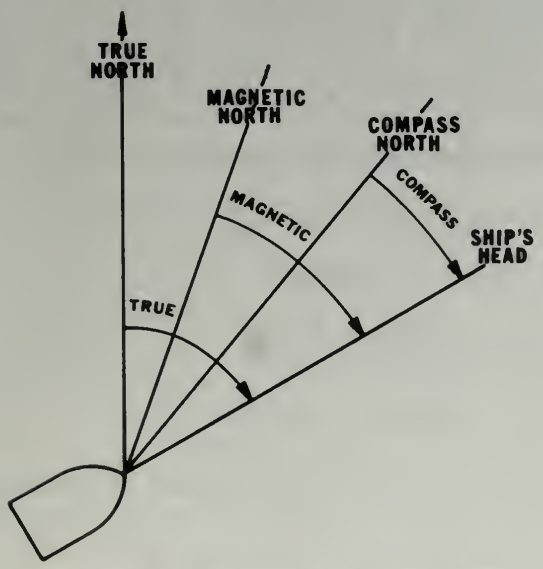
Subtracting the easterly variation by formula, the magnetic course would then be 080°. You would then have:

T	V	M	D	C
095	15E	080		

Assume that your deviation table shows a deviation of 4°W for a magnetic heading of 75° (as close as we can come to 080°). You can then finish your formula as follows:

T	V	M	D	C
095	15E	080	4W	084

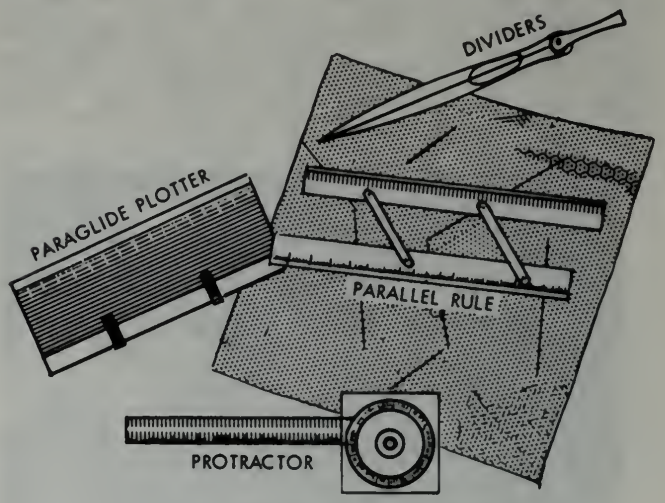
Your compass course then becomes 084°. You can go from compass course to true course simply by reversing the minus and plus signs for variation and deviation. Although this method of calculation has taken a long time to explain, once the formula is learned the calculation can be done easily as a mental problem.



7-6 Naming Directions

Piloting Instruments

The basic items necessary for piloting consist of charts of all the areas in which you do your boating



7-7 Plotting Instruments

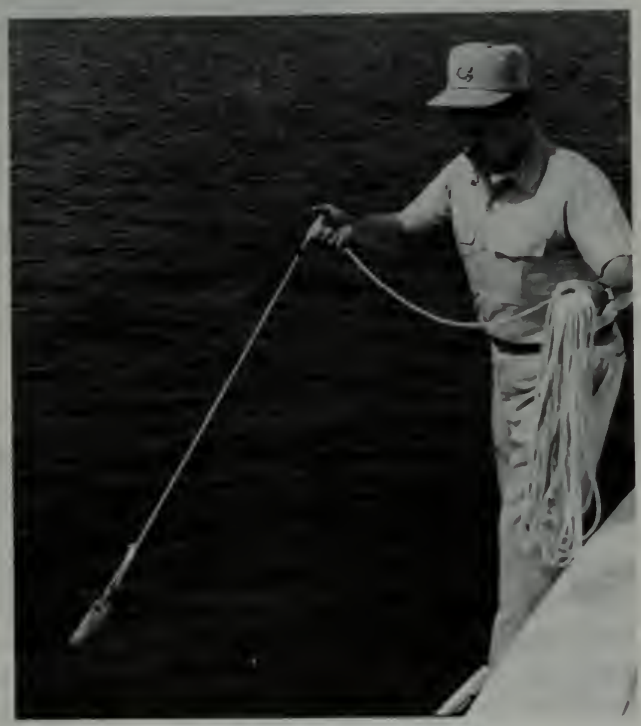
and a compass suitable to your boat. In order to plot a course on a chart and determine the direction of that course, some method of drawing a straight line and determining direction on the chart must be added. A set of parallel rules will serve both purposes. A course protractor will also do a good job. On most small boats an arm-type course protractor is much easier to use than are parallel rulers. Some arm-type protractors have distance scales on the arm that match the most commonly used coastal chart scales. The alternative is to add a pair of dividers to your kit. These dividers, a compass, parallel rules, several sharp pencils, and a soft eraser, are all you will really need in order to plot a course on a chart. There are other piloting instruments that are handy to have, and in some cases are highly desirable, if they fit your boat and your type of boating.

Sounding Devices

In some waters an old fashioned lead line with a tallow pocket in the bottom of the lead will be helpful in determining the depth of the water and the nature of the bottom as an aid in locating your position. In other waters, a good cane pole or boat hook is sufficient for an immediate sounding device, especially on small boats in shallow waters.

The fathometer, an electronic depth finder, is

useful in deeper waters. It warns of shallowing bottom and can help determine your position if you check the water depth on a chart. A fathometer can be used to run along the edge of a dredged channel in a fog. This serves the dual purposes of guiding and keeping you on the edge of the channel away from larger vessels which may still be moving in the middle of the channel.

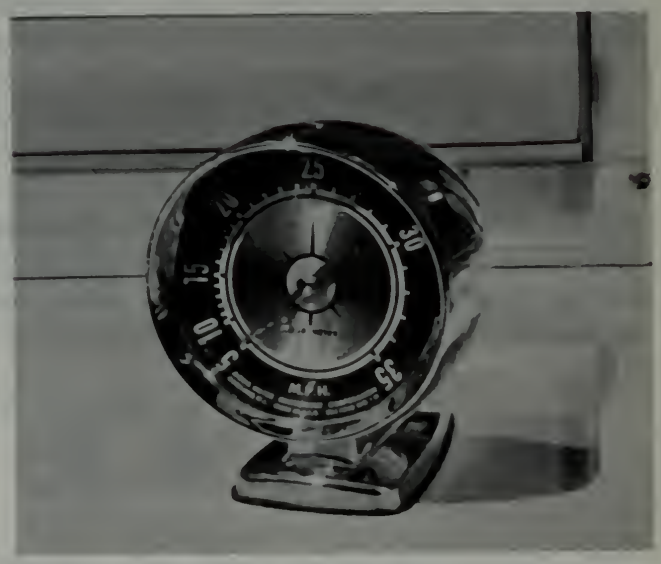


7-8 Sounding the Bottom

Logs and Speedometers

A log is an instrument that indicates distance run. The most common is the "taffrail log", so named because on old sailing ships the readout portion was attached to the taffrail. It is composed of three major parts: (1) a distance readout, usually one or two dials; (2) a rotor (spinner) similar to a streamlined propeller and; (3) a log line. The boat's forward motion causes the rotor, which is trailed behind the boat, to spin. The log line transmits the revolutions to a set of gears within the readout device, which activates the distance pointers. Taffrail logs, generally, tend to over-read when going into a sea and under-read when going with the sea.

There are many types of marine speedometers available to the boatman. It is most important to remember that all marine speedometers measure speed *through the water*. Corrections for set and drift of the current must be made in order to determine speed over the bottom. Speedometers should be calibrated when installed, and checked periodically. Some speedometer manufacturers offer an accessory which computes the distance run. An alternative to having a log or speedometer is to construct a speed curve for your boat.



7-9 Speedometer

The Speed Curve

Speed, Time and Distance

The formula (Distance = Speed × Time) can be used to determine boat speed for any given engine speed. In the formula distance is expressed in nautical or statute miles, and time is expressed in hours. Since it is easier to express time in minutes than in hours, the constant 60 is inserted into the formula which then becomes:

$$\text{Distance} = \frac{\text{Speed} \times \text{time (minutes)}}{60}$$

the other two forms are:

$$\text{Speed} = \frac{\text{distance} \times 60}{\text{time (minutes)}}$$

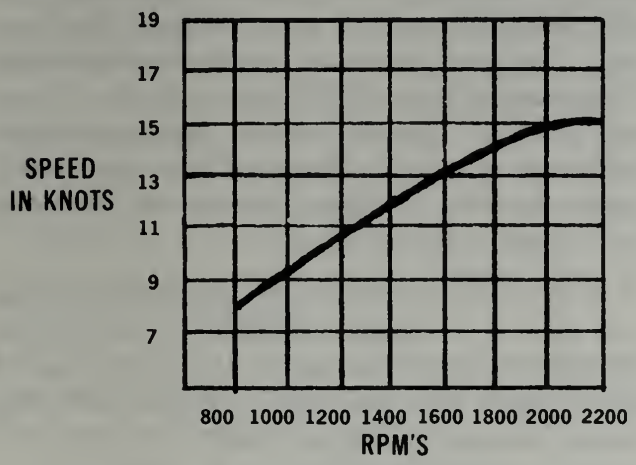
$$\text{Time (minutes)} = \frac{\text{distance} \times 60}{\text{speed}}$$

One word of caution—If distance is measured in nautical miles, your speed is expressed in knots. If you measure your distance in statute miles, your speed is then expressed as miles per hour. If you

learn one form of the equation the others can be derived from it; or you can copy all three forms along with TVMDC on small cards. Always keep one card on the boat and take the other to classes, exams or any other place you may be working piloting problems.

Constructing a Speed Curve.

The speed, time and distance formulas (page 128) can be used to construct a speed curve. This is a chart or graph which shows speed through the water for any engine speed (rpm). Each boat has a different speed curve. This is a typical speed curve



7-10 A Typical Speed Curve

for a displacement type cruiser. In the example, the distance between buoys was measured on the chart as .85 miles. The method shown here is applicable to your own boat. The data for the curve was gathered by running *both* ways over a known distance at various engine rpm's, noting the elapsed time with a stop watch. After calculating the over-the-bottom *speeds* each way and averaging each pair of answers to offset possible wind and current factors, the net result establishes the "through-the-water" speed for each rpm setting. *Do not* average the *times* since this will not give the same results. A smooth curve drawn through the plotted points on the graph completes the project.

Speed Trial Tabulation Over Measured Mile

RPM	N-S		S-N		Average Speed	Current
	Time	Speed	Time	Speed		
800	6m 47s	8.85	8m 32s	7.03	7.94	.91
1000	5m 46s	10.41	7m 31s	7.98	9.18	1.23
1200	5m 01s	11.96	6m 46s	8.87	10.41	1.55
1400	4m 28s	13.43	6m 13s	9.65	11.54	1.89
1600	4m 03s	14.82	5m 47s	10.38	12.6	2.22
1800	3m 42s	16.22	5m 01s	11.96	14.09	2.13
2000	3m 31s	17.06	4m 53s	12.29	14.67	2.39
2200	3m 24s	17.64	4m 41s	12.81	15.22	2.42

7-11 Speed Table

Using a Speed Curve

By using a speed curve, you can select a suitable rpm for any given water conditions and have a fair idea of your through-the-water speed. In adverse conditions, an estimate will have to be made of the effect of wind or current on your through the water speed to arrive at the actual over-the-bottom speed.

Determining ETA

If you know how far you have to go (obtained from the chart) and how fast you are going (from the speed curve) you can determine how long it will take to reach your destination. For example, if your destination is 22 miles away and your speed is 8 knots, you can determine that it will take 165 minutes (2 hours 45 min.) as follows:

$$\text{Time in minutes} = \frac{\text{distance} \times 60}{\text{speed}}$$

$$\text{Time} = \frac{22 \times 60}{8}$$

$$= \frac{1320}{8}$$

Time = 165 minutes (2 hours & 45 minutes)

All that is necessary then is to add 2 hours 45 minutes to the time of departure to determine when you should arrive. However, this method of determining ETA does not take into account the effects of wind and/or current and therefore is only approximate.

The Radio Direction Finder

One final instrument which is useful to the offshore fisherman and cruising boatman is the radio direction finder or RDF. For those who actually do a lot of offshore sailing, this is a most useful

electronic aid. Some very fine ones are available at a modest price.

Full instructions are usually provided with the instrument and should be studied carefully. Briefly, the procedure for operating an RDF is as follows: The instrument is placed with the lubber's line parallel with the keel. The 0° point of the azimuth scale is then set on the lubber's line. The radio bearings recorded will be relative bearings and must be added to the vessel's course at the time the bearing is taken. To obtain a bearing, the following steps should be followed:

(1) Select a station which has a known location
(2) Tune the set for maximum signal strength
(3) Rotate the antenna to obtain the null or weakest signal (usually indicated on a meter)
(4) Call "mark" to the helmsman (helmsman notes the compass heading)
(5) Read the relative bearing indicated on the RDF

The bearing obtained will be either the bearing towards the station or its reciprocal. Most RDF's have an additional "sense" antenna which assists in identifying the correct bearing as opposed to the reciprocal bearing. Most RDF's have three bands: a low frequency band covering the Coast Guard RDF stations and the aero beacons; the standard broadcast band; and the marine 2 to 3 megaHertz band. The Coast Guard low frequency stations will give the most accurate readings, but any station whose transmitter *can be located on the chart* will give a usable reading.

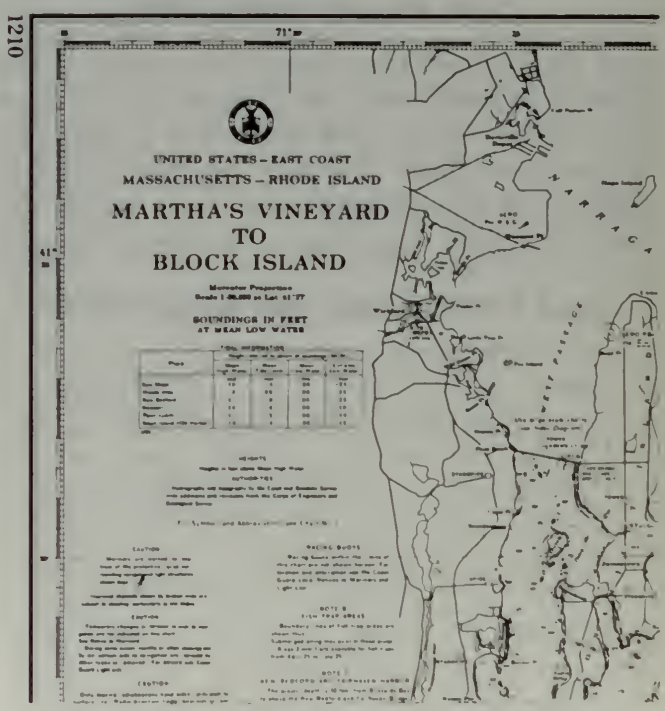
However, before you decide that this is the aid you must have, let's take a look at the other side of the coin. Your RDF is subject to its own form of deviation errors, caused principally by re-radiation of the incoming radio signal from metallic objects aboard your boat. This could cause dangerous errors in these bearings. Hence an RDF deviation card is a must. Further, radio bearings are not as accurate as visual bearings, and are usually subject to at least a 3° plus or minus error.

Properly used, the RDF is a useful aid to navigation. Improperly used, it can be dangerous, so temper your enthusiasm with some cold calculation. Will you take the time and trouble to calibrate your set and learn to use it properly in good weather before you need it at night in bad weather?

Marine Charts

To travel with relative peace of mind while boating, it is necessary to be familiar with the area. When in your "home waters" your own knowledge and experience will probably enable you to miss the shallow spots and any other obstacles that exist. Outside of your home waters, however, it is a different story. Just as you need a road map on unfamiliar highways, you need a nautical chart to help you on unfamiliar waters. While a road map will show you approximate locations of items such as airports and parks (landmarks) a chart will show you the *exact* position of those major landmarks which are visible from the water. Later you will be shown how to use these landmarks to determine your position on the chart.

A chart also shows channels and the locations of the aids to navigation discussed in the previous chapter. The depth of water, the composition of the bottom, clearance under bridges and other useful information is also shown.



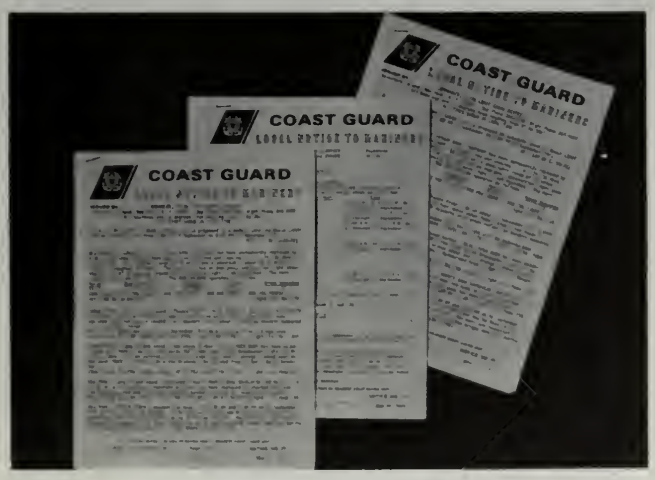
7-12 Descriptive Portion of Chart 1210

Your class may be instructed on your local chart, however, Chart No. 1210TR is often used for instructional purposes. This specially printed "training Chart" is a very good example of a coastal area chart. As an added dividend much of the material shown on Chart #1 has been reproduced for you on the back of this chart. Spend as much time as you can studying this material. If you do not have #1210 TR (note that this is not the regular issue 1210 Chart), then by all means secure a copy of *Nautical Chart Symbols and Abbreviations—Chart #1* from your chart source.

Time spent studying either of these references will add greatly to your ability to read and understand your local chart and any other chart you may have occasion to use. Before using a chart for the first time, there are several items of essential information which should always be determined. Some of these are: the unit of depth measurement (either feet or fathoms), the scale, the limits of coverage and restricted areas, all special notes and the date of the chart.

One thing to keep in mind at all times is that charts can never be 100% accurate. Lights on aids to navigation may be extinguished; buoys can drift or be dragged out of position. There are numerous occurrences that can affect the accuracy of a chart. For this reason, the prudent mariner uses a chart as an aid and not as an infallible source.

It is extremely important to use an up-to-date chart. Without a current chart you may be ignorant of the existence of new underwater obstructions



7-13 Local Notice to Mariners

NOTICE - The U. S. Department of Commerce, Environmental Science Services Administration, Weather Bureau, Boston, Massachusetts, advises that the visual storm warning display station located at the U. S. Coast Guard (Winter Island) Air Station, Salem, Massachusetts, was terminated 1 September 1970.
Approximate position: 42°31.6'N., 70°52.2'W.
Reference: LNM 15 (CG Boston) 15 April 1970.

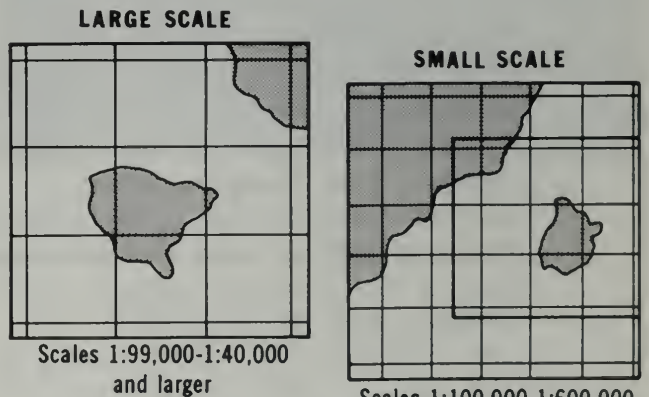
MASSACHUSETTS - Boston Harbor - President Roads - The New England Aquarium, Boston, Massachusetts, advises that NEW ENGLAND AQUARIM POLLUTION LIGHTED BUOY (IL No. 440.41) an orange and white toroid shaped buoy showing a flashing white light every 11 seconds has been permanently established about 240 yards 095° from Dear Island Light (IL No. 440). (Private Aid)
Approximate position: 42°2D'23"N., 70°57'09W.
C&GS Charts: 246, 246-SC, 248, 248SC.
Reference: LNM 31 (CG Boston) 5 August 197D.

RHODE ISLAND - Rhode Island Sound - Narragansett Bay Approach - AMERICA'S CUP RACES, sponsored by the NEW YORK YACHT CLUB, will be held daily commencing about 1100 on 15 September and continuing until one contended wins four races. Races will be within a 5 mile radius of AMERICA'S CUP RACE LIGHTED GONG BUOY AC (IL No. 79.21) located 7 miles 143° from Brenton Reef Light. Participants will be two 12 meter sailing vessels the "GRETEL II" representing Australia, and the "INTREPID" representing the United States.
The race will be patrolled by U. S. Coast Guard patrol craft.
Mariners are requested to exercise caution in this area and to stand clear of sailing vessels participating in these races.
Special Local Regulations for the 1970 America's Cup Races issued by the Commander, First Coast Guard District are enclosed for the information of

EXAMPLE OF "NOTICE"

such as shoals, wrecks, or new, moved, or discontinued aids to navigation. Charts may be kept up to date by making corrections listed in the regularly issued "Notice to Mariners" and "Local Notice to Mariners." All charts printed by the National Ocean Survey (formerly the Coast and Geodetic Survey) are dated. The date is located in the lower left hand corner of the chart. The edition number is printed next to the date in the following manner: 12th ED., June 10/70. When an edition is revised, the date of revision is also shown: 12 ED., June 10/70; Revised 4/4/71.

A new edition makes all previous printings obsolete. A revised edition, however, does *not* make previous printings of the same edition obsolete. When the 13th edition of a chart is printed, all printings of the 12th edition will become obsolete.



7-14 Large and Small Scale Charts

Charts are made in different forms for different purposes. Large scale charts (up to a scale of about 1:20,000) cover a relatively small area and are used

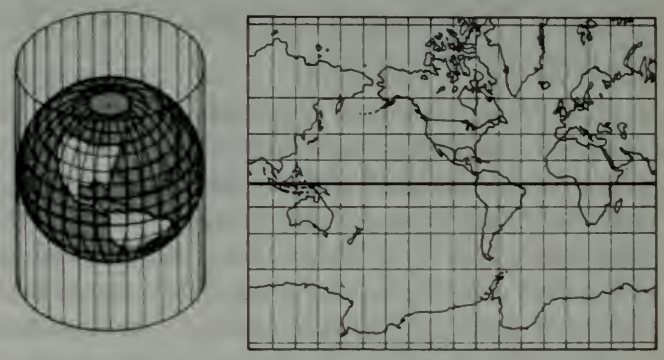
to show local features such as harbors and channels. Small scale charts (average scale is about 1:1,200,-000) cover a relatively large area and are used to cover great distances as in sailing charts used for transoceanic voyages. In between these extremes, other scales are used which best suit the purpose of portraying a section of coastline or an area such as a large bay or sound. We also have some very excellent aids to small boat navigation for popular areas which are called Small Craft Charts. These are designated by the initials "SC" after the chart number. The Small Craft series is published in folder form. In addition to being conveniently sized for the small boat operator, these folders include condensed tide tables, wind scales, time and source of weather broadcasts as well as other useful nuggets of local information. Most small craft charts are identical to regular charts, the only difference being that they are folded and placed in a folder. If this is the case, both charts will bear the same number but on the small craft chart, the number will be followed by the initials "SC." Other small craft charts are completely original. Consult the catalogue at your chart source to determine the charts available for your area.

Projections

There is an inherent problem in representing the spherical shape of the earth on the flat surface of a chart. Four commonly used methods (projections) of showing the earth on a chart are:

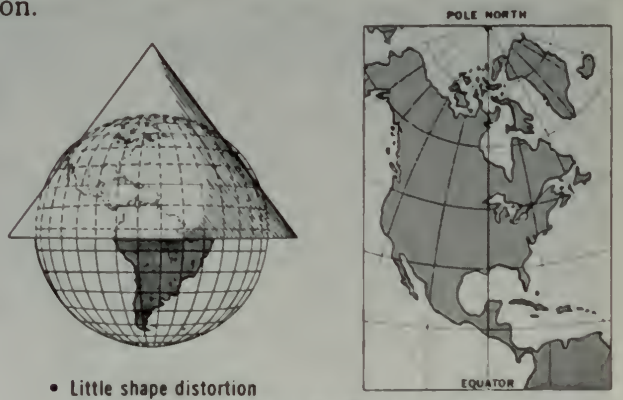
1. *Mercator projection:* used for coastal and sailing charts as well as large scale harbor charts. In the maritime world this is our most important and most frequently used projection form for coastal areas.
2. *Polyconic projection:* used by the Corps of Engineers and the Lake Survey for the charts of the Great Lakes and other northern lakes under their jurisdiction.
3. *Gnomonic projection:* used for ocean sailing because of ease in plotting great circle courses (shortest distance between two points on earth).
4. *Lambert Conformal:* used for many air navigation charts. The last two are not used in small craft piloting and will not be discussed further.

The basic advantage of the Mercator projection is that all *vertical* lines representing meridians of longitude and the *horizontal* lines representing the parallels of latitude intersect at right angles (90°). This means that when we draw a course line on the chart from point A to point B, that line crosses all meridians at the same angle. This so called "rhumb" line is easy to draw since it is simply a straight line. From compass roses conveniently located on the chart it is easy to determine the direction of the rhumb line. If we transfer this course line to a globe and cross all of our meridians at the same angle, we would find that our course line is no longer straight but instead is a curve spiraling to the pole. For short distances (a few hundred miles) the extra length of our curved course line over the length of a great circle route, which is a straight line on our spherical earth, would be negligible. By understanding our rhumb line courses, we can use them without further concern and enjoy the simplicity of Mercator navigation.



- Angles are correctly represented
- Great circle appears curved
- Rhumb line appears as straight line
- Distortion in BOTH directions

7-15 Mercator Projection



- Little shape distortion
- Parrallels and meridians do not meet at right angles
- Scale correct along all parallels and the central meridian

7-16 Polyconic Projection

Latitude and Longitude

There has long been a system, based on the geometry of a sphere, whereby the location of any point on the surface of the earth can be described by two coordinates. These two coordinates are called latitude and longitude. Latitude is the North-South coordinate and longitude is the East-West coordinate.

For example, the coordinates of Key West, Florida, are 24°33′N, 81°49′W. This is read as twenty-four degrees, thirty-three minutes North (latitude); Eighty-one degrees, forty-nine minutes west (longitude).

Latitude is measured from 0° to 90°, with 0° being at the equator and 90° at the poles. The direction from the equator is indicated by a letter, N for north of the equator (nearer the North Pole) and S for south of the equator.

Longitude is measured from 0° to 180,° with 0° being located on the line drawn from the North Pole to the South Pole, passing through Greenwich, England and 180° being on the opposite side of the earth. The International Date Line runs along this 180° line. The direction from Greenwich is indicated by a letter, E for east of Greenwich (towards Europe) and W for west of Greenwich (towards America). All positions (locations) in North America are in north latitude and west longitude. Positions are often defined to the nearest tenth of a minute (.1); for example 33° 28.1′ N.

Describing Position by Latitude and Longitude

Knowing your position is important but being able to describe that position to someone else is also important, especially in an emergency. Unless you are very close to an identifiable landmark or aid to navigation, the best way of describing your position is by the coordinates discussed earlier, latitude and longitude.

Measuring Distance on a Mercator Chart

Distance on a Mercator chart is always measured on the latitude scale. This is the scale appearing on the left and right sides of a chart. One nautical mile equals one minute (1′) of latitude (a mile a minute). Since there are 60 minutes in one degree, one degree of latitude equals 60 nautical miles. Since there are 360° in a circle, the circumference of the earth is 21,600 nautical miles. By dividing this figure into the circumference of the earth established by international agreement, we find that a nautical mile is 6076.1 feet long. This is approximately ⅛ longer than the 5280 foot statute mile.

One characteristic of a Mercator chart is that the size of areas is distorted. Because of this distortion, one minute of latitude will appear to get larger when moving away from the equator. On large scale charts, up to about 1:80,000, it makes very little practical difference where we measure along the latitude scale, for the change in scale from top to bottom of the chart is very slight. However, for smaller scale charts covering larger areas the difference in the length of a minute of latitude is easy to find from top to bottom of the chart, and it becomes a factor in accurate chart work. Therefore, it is good practice to make it a habit to always measure at about the mid latitude of the course line on all charts.

7-17 Measuring Along the Latitudes Scale

Measuring Distance On A Polyconic Chart

On a Polyconic chart, distances which are generally in a north-south direction can be taken directly off the latitude scale since the length of one minute of latitude appears the same length on every part of the chart. Distances which are more east-west cannot be measured accurately using latitude and it is best to use the bar scale for statute miles which appears on all Great Lakes charts. To avoid possible confusion when piloting, all distances

on a polyconic chart should be measured in statute miles using the bar scales.

Obtaining Charts

Frequently charts can be obtained locally through marine dealers who handle them as a service to their boating customers. There is no assurance that these will be up to date, so always look at the date of issue stamped on the chart by the official agency and be your own judge as to whether you want that copy. In most areas it is safest to replace charts at least every year or every two years at the latest. Generally, new editions of Small Craft charts are produced on an annual basis. In most major ports you will find an official chart agency that handles marine charts and other publications for the shipping trade. For those without access to these sources, the government sources are as follows:

Other Published Aids To Navigation

We mentioned other publications available from chart agents. Some of these you will want to have; some you will probably have little use for. We list them briefly, with the prime source in case you cannot buy them locally.

1. *Chart #1*—in pamphlet form. Previously mentioned.
   Source: National Oceanic and Atmospheric Administration (NOAA)
2. *Coast Pilots*—In eight volumes—See chart catalog for listing areas covered in each volume. These contain much information essential to the cruising boatman, or to one who requires detailed information of an area.
   Source: NOAA
3. *Tide Tables*—In four volumes.
   Source. NOAA
4. *Tidal Current Tables*—In two volumes.
   Source. NOAA

Items 3, and 4 are especially necessary to east and west coast boatmen, particularly in the upper latitudes where tides and currents become a major factor in navigation.

5. *Light Lists*—In five volumes. Published by the Coast Guard.
   Source: Superintendent of Documents, Government Printing Office, Washington, D. C.
6. *Intracoastal Waterway*—In two volumes.
   Source: Superintendent of Documents, Washington, D. C.
7. *Notice to Mariners*. The Local Notice to Mariners is of most use to the small boat operator.
   Source: Apply to your local Coast Guard District Commander.
8. *Rules of the Road*—In three Volumes, as given below. Published by the Coast Guard.
   Source: Superintendent of Documents, Washington, D. C.
   CG-169 International-Inland Rules
   CG-172 Great Lakes
   CG-184 Western Rivers

Plotting

To complete our study of piloting we need to take the things we have learned about charts, compasses, and piloting instruments and put them together in actual practice. In any piloting situation, the answers to be determined are usually concerned with either establishing a course line or determining position. The determination of position may be the whole problem, but most of the time position is only a point necessary to the fixing of a course line to another destination. True courses are always used in plotting on ships and it is good practice to use only true courses on your charts. It is accepted practice amongst all experienced boatmen and is most necessary in the plotting of relative bearings, and in the positioning of your vessel.

Time

Time is displayed on a chart by using the 24 hour system. In this system the first two digits tell the hour (01 to 23) and the last two digits give the minutes (00 to 59). Midnight is 0000. Thus 9:45 AM is written as 0945, while 9:45 PM is written 2145.

Plotting Symbols

There are several terms and symbols which are used in piloting. You should be completely familiar with these before proceeding.

—A *"line of position"* (LOP) is a line, from a

known position, along which a vessel is presumed to be located. LOP's are commonly obtained by taking a bearing on a charted object. A line of position is labeled with the time and bearing *to the object.*

It is indicated on a chart as:

$$\frac{0930}{100}$$

When a LOP is obtained by sight along a range only the time is shown, as: 0930

—A *"fix"* is an accurate position, usually obtained by crossing 2 or more LOPs. A fix is indicated on a chart as:

0945 FIX

—A *"running fix"* is a position determined by crossing 2 LOPs, which were obtained at different times. A running fix is indicated on a chart as:

0945 R FIX

—A *"DR Position"* is a position determined by applying a vessel's course(s) and speed(s) to the last accurate position. A DR position is indicated on a chart as

0945 DR

—An *"estimated position"* is the most probable position for a vessel, determined from bearings of questionable accuracy. It is often a DR position modified by the best information possible. An estimated position is indicated on a chart as:

0945 EP

The "DR" Plot—The Dead Reckoned Plot

If our cruise is to be of considerable length, it is customary practice to set up our DR track. This is simply a plot of our course marked with hourly positions, determined purely from speed based on engine RPM and our speed curve. For sailing craft, this would have to be speed as estimated by some form of log or speedometer.

If along our course, there are certain landmarks from which we can accurately determine our position, this would be done and these positions would be plotted and compared with our DR position for the same time. This will tell us much about our progress.

The comparison of the DR positions with the actual positions will help us arrive at some very valuable conclusions regarding the effect of wind, current, and steering error on our progress. Naturally, one fix will not answer any question except whether or not we are on course, but a series of positions compared with the DR plot will provide these answers. However these calculations are beyond the scope of this text. As we have indicated previously, this type of piloting is more practical in cruising than in day sailing.

Plotting DR

Outside of most harbors there is a buoy or some landmark to mark the entrance to the harbor from which we can take departure, and another, toward which we can sail. If we draw a line through these points on our chart, we have laid off our course line. Be sure that there are no physical obstructions shown on the chart in the way of a course line. Changes in course are necessary sometimes, to avoid these obstructions.

If we are using parallel rules, we can walk the course line up to the nearest compass rose and read the direction of our course on the ring of the rose. If we are using a pivoted arm course protractor we would place the pivot point over the point of departure and align the horizontal or vertical lines of the protractor head with the nearest meridian or parallel on the chart. Then by

7-18 Parallel Rules

swinging the arm to align with the course line, the true course angle can be read on the angular scale of the protractor.

If you are using a swing-arm course protractor, you must apply the local variation to arrive at the magnetic course. Then apply the deviation, if any, to arrive at the ship's heading—the compass course. Remember we never plot compass or magnetic courses. We plot all courses as true and by mathematical (TVMDC) application we arrive at our compass course.

The true course is indicated on the chart.

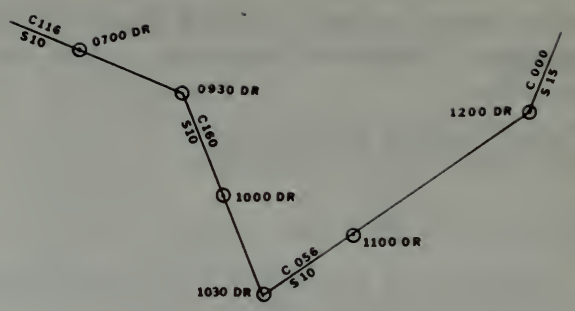
After your course has been set, it should be standard operating procedure for you to mark off the distance to be run with your dividers. Estimating the speed of your boat from your speed curve, and knowing the distance to be run, it will be very easy to estimate your time of arrival at your next reference point. This procedure is a must in periods of low visibility, such as fog.

7-19 Calculating Distance of Run

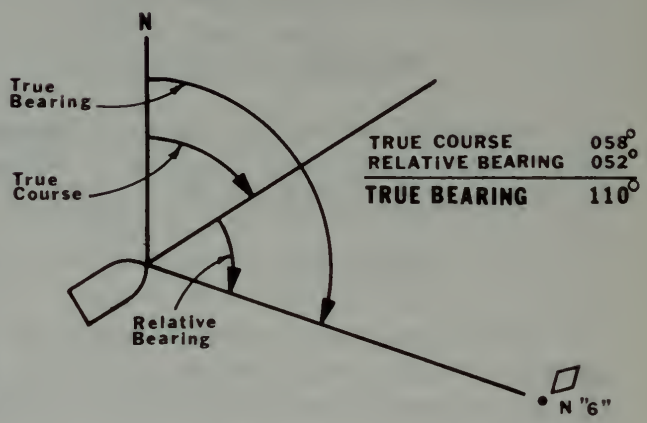
The "rules" for when to update a DR are:

1. Every hour on the hour
2. Whenever there is a course and/or speed change
3. Whenever a FIX, R FIX or an EP are obtained.

Additionally, a new course line is started from every FIX or R FIX. Also, more frequent plotting is appropriate when in channels or other restricted waters.



7-20 Typical DR Plot



7-21 Converting Relative Bearing to True Bearing

Bearings

A bearing is the horizontal direction of one object from another. It is usually expressed as the angular difference between a reference direction and the given direction. In navigation, true north is generally used as the reference direction and the given direction is expressed in angles measured clockwise through 360°.

The instrument used for measuring this angle is called a pelorus, which is a non-magnetic, rotative compass card with a sighting vane. In application, the object which is to be used for the bearing is sighted through the vane and the value of the angle is read directly from the card.

Depending upon the reference direction, the bearing is either relative or true. If the 000° mark on the pelorus is parallel to the keel line, the bearing is relative. If the 000° is pointing toward true north, the bearing thus obtained is a true bearing.

7-22 Pelorus

Plotting A Line Of Position (LOP)

From any given charted landmark or aid to navigation, on which a bearing has been taken, a dotted line is drawn in TRUE direction to intersect your course line. By adding or substracting 180° from the given direction you can then plot your LOP with the time in four digits above the line and the true direction in three digits below it. You know that your vessel is somewhere on this line.

One word of caution: ALWAYS correct a compass bearing to a true bearing through the TVMDC formula before plotting.

Plotting A Fix

A FIX is obtained by taking and plotting cross bearings on two or more charted objects. In the diagram 7-23 entitled "CROSS BEARINGS—TWO LANDMARKS," assume that you are proceeding in an easterly direction. At 1215 you sight a monument off your port bow and over your compass you take a bearing on it. Remember, this is a compass bearing and therefore must be corrected to a true bearing by using the TVMDC formula. This true bearing of 053° is then plotted on your chart. Time is shown above the line, and the bearing below the line. Also at 1215, you sight a water tank over your port quarter, and after making the proper corrections, you find that it bears 312° from your vessel. This second bearing is plotted on your chart. Each of these plotted lines is a line of position (LOP) and in each instance you are somewhere on that line of position. Obviously, you are at the point where these two lines

7-23 Cross Bearings—Two Landmarks

intersect, which establishes your 1215 FIX, providing you plotted it correctly.

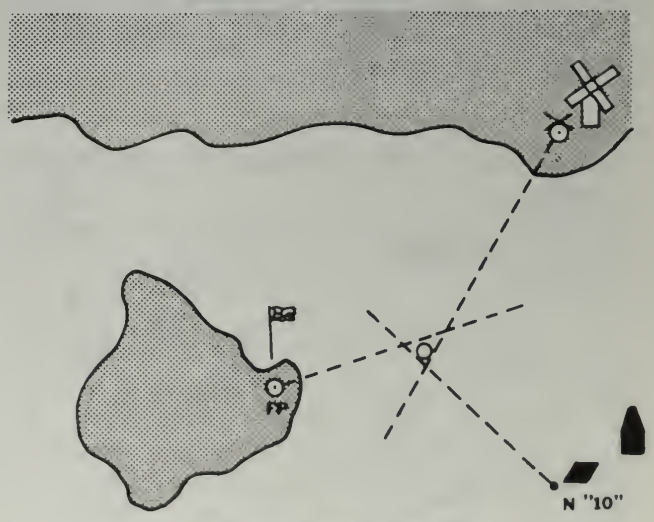
Another word of caution: in correcting your compass bearing for deviation ,you MUST use the deviation correction for the ship's heading.

In labeling the bearing as to angle value and time, we refer you to the material relative to plotting symbols earlier in this chapter. A new DR line would be started from this fix.

Three Bearing Fix

Whenever possible it is best to obtain three bearings when fixing your position.

In this case you plot your FIX position in the center of the triangle formed by the bearings. Again, a new DR line would be started from this FIX.



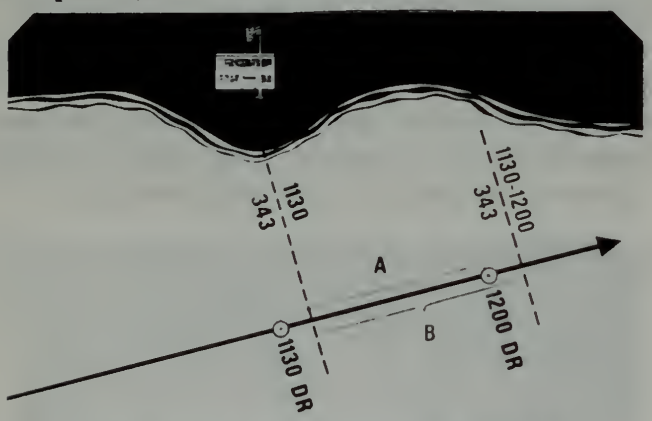
7-24 Three Bearing Fix

For best results always pick objects which will give the best angle. For two-bearing fixes, the angle of intersection should be as close to 90 degrees as possible. For three-bearing fixes this angle should be near 60°. (See 7-24 Three Bearing Fix.)

Advancing An LOP

In order to allow for the difference in time we must "advance" the first LOP along the DR plot. The distance advanced is equal to the distance run from the time the first LOP is obtained to the time the second LOP is obtained.

The result is a line on the chart which is parallel to the first LOP and moved forward along the DR plot. (See 7-25 Advancing An LOP.)

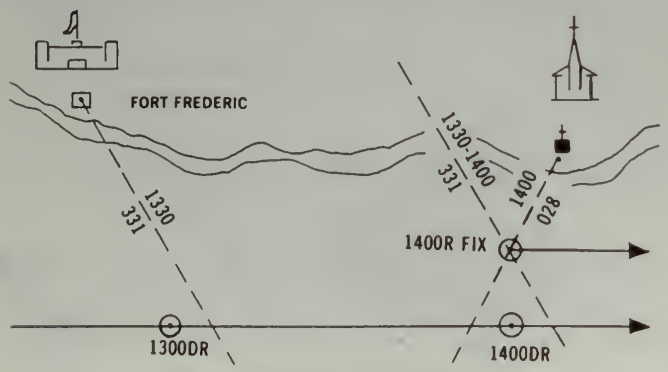


When advancing an LOP, distance A equals distance B

7-25 Advancing An LOP

Plotting A Running FIX

It is often impossible to obtain two bearings at the same time. When this happens we must obtain a running Fix (R FIX) which uses two LOP's obtained at different times.



7-26 Running Fix

Completing the R FIX

The running fix is obtained by crossing the advanced LOP with another LOP. Again, a new DR plot is started from the fixed position.

Since this process depends on the accuracy of your dead reckoning, an LOP should not normally be advanced for more than 30 minutes, although, in some cases, it may be necessary to exceed this time.

This concludes our coverage of piloting. For further study, the following books are recommended:

(1) *Piloting and Dead Reckoning,*
H. H. Shufeldt and G. D. Dunlap,
U.S. Naval Institute

(2) *Dutton's Navigation and Piloting*
G. D. Dunlap and H. H. Shufeldt
U. S. Naval Institute

(3) *American Practical Navigator*
N. Bowditch
U. S. Navy Hydrographic Office

CHAPTER 8

Marine Engines

Introduction

The gasoline powered marine engine has been used as a propulsion unit for many years; in fact, history records its use in the 6000 mile voyage of a 35′ craft in 1911, only eight years after the Wright brothers first engine powered heavier than air flight. In the ensuing years, the gasoline engine has become the source of power used most by small craft. In 1972, statistics indicate that there were more than 700,000 inboard boats in use, including auxiliary powered sailboats and documented boats; some 800,000 diesel and gasoline engines, including those converted from automotive engines; 7,400,000 outboard engines; and some 300,000 inboard-outdrive units. The estimated cost of these engines in use in 1972 exceeds the original cost of the Pentagon.

This chapter will be devoted to the care and maintenance of the "brute that powers" the small craft fleet. With this thought in mind, let us consider that no part of a boat is more important than the engine. A good skipper will be sure that the engine is properly maintained and cared for at all times. If neglected, many long hours of hard work will inevitably result. To properly maintain the engine, a place should be set aside for tools and spare parts. These should be replenished as needed and every spare part should be in good working order.

The engine and engine compartment should be kept clean at all times. Regular cleaning requires little effort, but if this care is neglected, a difficult job will follow. Never leave oily rags or papers lying around - they could create a hazardous situation. Keep the engine compartment clean and well ventilated and the possibility of fire or explosion will be minimized. For boating safety, ventilation of the engine and fuel compartment is one of the most important factors to be observed.

One other word on safety - safety for others, and for your protection. NEVER leave the keys in the ignition switch after the engine has been stopped. There is always the possibility of accidental ignition (such as a child, or adult for that matter, falling against the key). The boat might also be stolen easily if someone can get in quickly and crank the engine.

Having considered several safety factors relating to marine engines, we will now proceed with the study of engines.

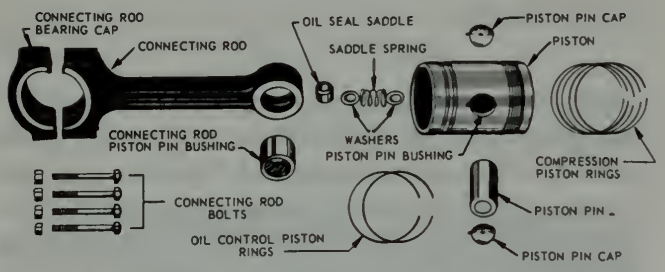
Almost all pleasure craft today are powered by engines. This is as true of sailboats as it is of powerboats since, except for sailing dinghys and certain small "class" sailboats, most sailboats are equipped with auxiliary engines.

Engines found on pleasure craft may be "inboard" or "outboard," in the sense that an inboard engine is installed within the hull while an outboard engine is installed on the transom (outboard of the hull) or mounted within an engine well. But, regardless of the method of mounting, all marine engines have a great deal in common. They are all intended to do the same job - to provide power to turn the propeller, which moves the boat.

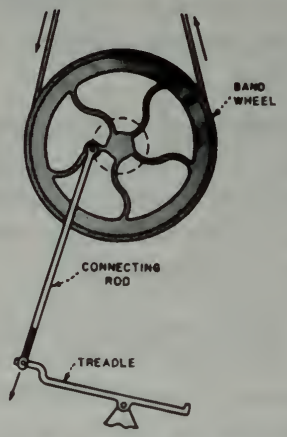
This chapter will deal with internal combustion engines and will cover the theory of operation of the four-cycle and the two-cycle diesel and gasoline engines. Routine maintenance and trouble shooting are reviewed.

All engines, except ramjets and rockets, are designed to convert an expanding gas into a rotating force. Let's look at the basic operation of reciprocating engines. A reciprocating engine is an engine with a piston that moves up and down. All reciprocating engines have three basic parts. The

first part is a cylinder which acts like a bottle to hold the expanding gas. The second part is the piston which fits snugly into the cylinder and is pushed by the expanding gas. The third part is the crankshaft which connects to the piston by a connecting rod and converts the reciprocating, or up and down motion of the piston, into a rotary motion. The crankshaft works like the pedals on a bicycle to convert the up and down motion of your knees to the rotary motion of the sprocket.



8-1 Piston and Connecting Rod Parts



8-2 The Crankshaft Action of a Treadle and Bandwheel

There are several ways to produce an expanding gas. Steam and hot air have been used as well as the more common explosions of the hydrocarbon fuels, such as acetylene, propane, gasoline, and oils. Gasoline, when mixed in the right proportions with air, will explode. An electrical spark can ignite this explosive mixture and the resultant explosion is an expanding gas. Oil, when sprayed into hot air, will also explode. Diesel, when he designed his engine, used compression to generate enough heat (1,000° F) to cause an explosion when oil was sprayed into the hot air at the proper moment. The term "internal combustion engine" is used whenever expanding gases are generated and contained in a cylinder.

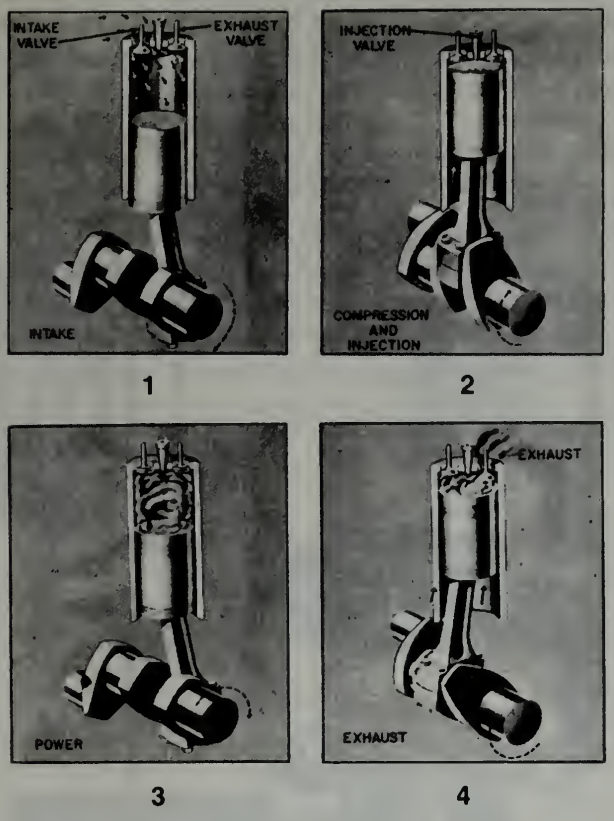
Internal combustion reciprocating engines require a proper mixture of fuel and air in order to run.

Before we study the theory of operation, we should first know what is meant by the terms "two-cycle" and "four-cycle." An engine runs by repeating a series of explosions over and over again. A cycle includes all the steps that are required to create one explosion in a cylinder. In a two-cycle engine, the piston moves two strokes - one down and one up - to complete one cycle. In a four-cycle engine, the piston moves four strokes - down, up, down, and up.

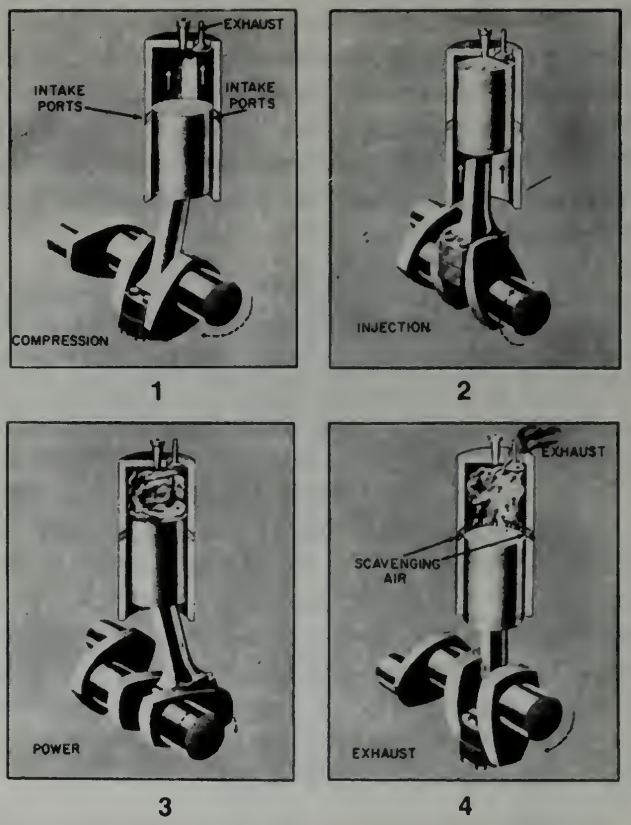
The Four-Cycle Engine

Let's start with the steps that are required to complete the cycle of a four stroke per cycle (four-cycle) gasoline engine. As the piston moves down in the cylinder for the first stroke, a vacuum is produced in the space above the piston. A valve (the intake valve) is timed to open at this instant, allowing an explosive mixture of gasoline and air to be drawn into the cylinder. This is the intake stroke. As the piston starts up on the second stroke, the intake valve closes, the cylinder is sealed, and the gas in the space above the piston is compressed. This is the compression stroke. Just before the piston starts down for the third stroke, an electrical spark - produced by the spark plug - ignites the explosive gas. The expansion of gas from the resultant explosion pushes the piston down. This is the power stroke. As the piston starts up in the fourth stroke, another valve (the exhaust valve) opens and the piston pushes the burnt gases out. This is the exhaust stroke. At the top of the exhaust stroke, the exhaust valve closes and the piston and cylinder are ready for the next four-stroke cycle.

Four-cycle diesels are similar to the gasoline engines except as follows: the diesel intake stroke does not draw in a gas/air mixture, only air. The air is compressed in the second stroke, but at a much higher compression ratio, producing an intense heat. The heat (1,000° F) is much higher than the ignition point of the diesel fuel. When the diesel oil is sprayed into the hot air, by injectors which atomize the oil into a fine mist, the oil explodes forcing the piston down for the third stroke, the power stroke. The fourth stroke is the exhaust stroke.



8-3 Four-Stroke Cycle Engine



8-4 Two-Stroke Cycle Engine

The Two-Cycle Engine

Two-cycle engines are harder to explain because the functions of intake, compression, power, and exhaust are not marked by each piston stroke, but may be combined. If we start with two-cycle diesels first, this will make it easier. We will begin the cycle immediately following the explosion. The piston is pushed down in the power portion of the stroke. Just before the piston reaches the bottom of the stroke, the exhaust passage is opened; then, the intake valve opens. Air which has already been partially compressed by a blower is forced past the intake valve into the cylinder. The incoming compressed air pushes out the burnt gases. Meanwhile, the piston has already started up on its second stroke. Halfway up, both valves close allowing the trapped air to be further compressed and heated. At the top of the stroke, the fuel is injected, explodes, and the cycle begins again. There are two reasons why compressed air is used in the two-cycle diesel; one is to help scavenge the exhaust gases and the other is to reduce the amount of compression required by the piston to achieve the final compression.

The two-cycle gasoline engine uses the same precompression technique; however, it is more complex than the diesel and a bit harder to explain. We shall consider the cycle function as a fuel flow, and interject, from time to time, the location of the piston as it travels through the strokes. There are two new things we should learn before we follow the flow path. The first new thing to consider is that a two-cycle gasoline engine has two working chambers. One chamber is the cylinder above the piston, with which we are already familiar. We will call this the upper chamber. The other chamber is located in the crankcase below the piston. We will call this the lower chamber.

The lower chamber is connected directly to the carburetor through a one-way valve which allows the gas/air mixture to be drawn into the chamber, but does not allow it to be pushed back.

These two chambers operate simultaneously but will have to be considered individually as we trace the flow path. We will consider the cycle of only one piston. When an engine has more than one piston, each lower chamber is separate and sealed from the

other chambers. The other new thing to consider is that the two-cycle gasoline engine does not have valves, as we saw on the previous engines, but ports. These ports are holes located in the sides of the upper chamber and are covered by the piston. These holes are covered until the piston is almost at the bottom of the stroke.

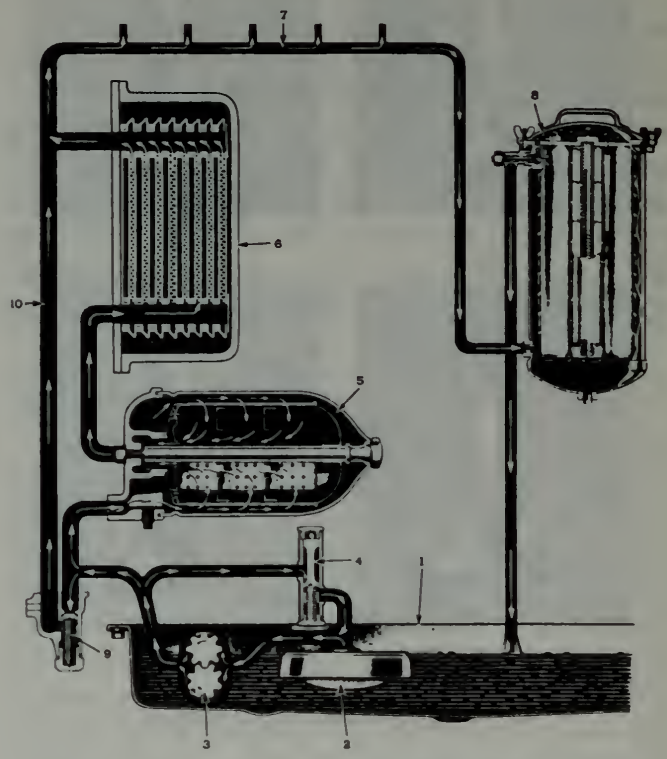
Let's trace the flowpath of the fuel through the two-cycle gasoline engine. As the piston moves up, the lower chamber becomes a vacuum, drawing an explosive gas/air mixture from the carburetor and, at the same time, an explosive charge of gas/air is being compressed in the upper chamber. At the top of the stroke, the compressed gas in the upper chamber is exploded, forcing the piston down. As the piston starts down, the mixture which is now trapped in the lower chamber is pressurized. Near the bottom of the stroke, the intake and exhaust ports are uncovered. The exhaust gases are forced out and are replaced by the incoming pressurized explosive misture. As the piston starts up, it closes the ports and a new cycle begins.

Internal combustion engines generate heat and, because they have moving parts, require lubrication. This means supplementary systems are required to run the engine efficiently.

Lubrication Systems

Any material which rubs or slides against another surface will generate friction and heat. This friction can never be eliminated entirely; however, there are many ways to reduce the amount of friction generated. One of the most common ways is to provide a thin soft film between the two sliding parts. In engines, the most common fluid used for this film is oil.

As there are many complex methods used to lubricate bearing surfaces, we shall cover only the most common found in marine engines. Engines are provided with channels or ducts which carry the oil to all moving parts in the engine. A pump is required to force the oil through these ducts. A reservoir of oil is located in a pan that is fastened beneath the engine. The oil is pumped from the lowest spot in the reservoir, the sump, through a screen that removes the large particles. Placed downstream of the pump there may be an oil cooler to remove the excess heat and a filter to remove the fine particles. On most engines, oil is ducted through the connecting rods and runs down the cylinder walls from the piston skirt.



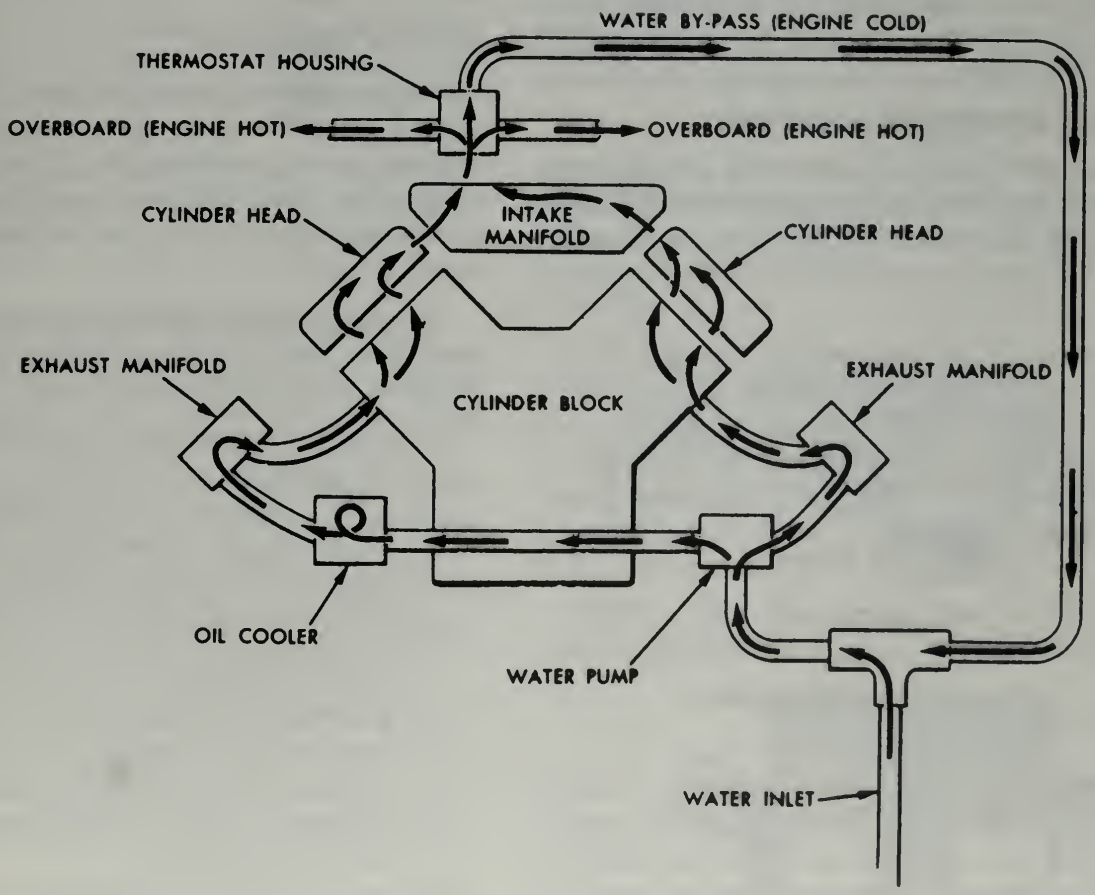
8-5 Lubrication System

In two-cycle gasoline engines, there is no oil reservoir, so the oil is mixed with the gasoline. The oil is suspended in the mixture as tiny droplets. When the gas/oil mixture is drawn into the crankcase, the gasoline, being more volatile, vaporizes, thus leaving some of the oil droplets to condense on the metalic surfaces. New oil is being supplied constantly; therefore, no filtering or cooling is required.

Cooling Systems

Water is the common agent used to cool marine engines. Some small outboards of two or three horsepower use air for cooling and are provided with fins to help dissipate the heat. Air-cooling is not efficient for larger engines except with the use of elaborate blowers requiring additional space and, if the exhaust system is run inboard, water cooling is

required for the exhaust manifolds and ducts. Marine engines may be cooled with raw sea water pumped in from outside the boat or with a closed fresh water cooling system similar to that used in cars. When raw sea water is used for cooling, only one pump is required. After the sea water passes through the engine, it is used to cool the exhaust manifolds and is discharged overboard with the exhaust. There are two ways to cool a closed fresh-water system. After the water is circulated through the engine by a water pump, it passes through a keel cooler, a type of radiator mounted outside on the hull of the boat, and is cooled by the sea water as the boat moves through the water. A separate sea-water pump is used to cool the exhaust manifolds and this water is discharged with the exhaust in the same duct. Keel coolers create a drag on the hull of the boat and may reduce the boat speed as much as two or three knots. If this loss of speed is a disadvantage, a heat exchanger may be used. The heat exchanger passes sea water over the cooling coils of the closed fresh-water system. The sea water that is pumped over the coils is then used to cool the exhaust manifolds and is discharged with the exhaust.



8-6 Water Cooling System

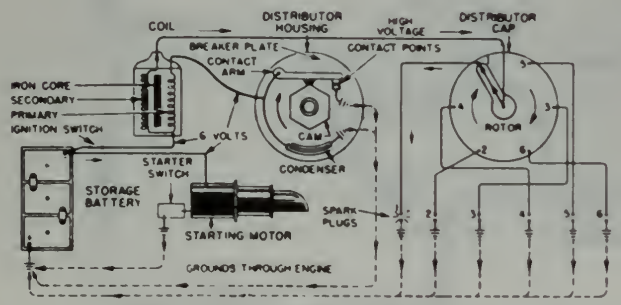
Fuel Systems

We have discussed explosive mixtures, but not how they are made. We will start with the simpler diesel systems. The fuel is pumped from the fuel tank through a coarse filter to remove large particles, then through a final filter, before entering the injector system. Each injector has a valve that not only passes the fuel to the injector, but also meters the amount to control the speed. In order to achieve a fine mist spray for complete combustion, the oil passes through an extremely fine hole in the injector at a very high pressure. The injectors are easily clogged, which means that extremely clean fuel and clean filters are essential.

Filtering is also essential for gasoline engines; for, after the fuel is pumped from the fuel tank into the carburetor, it passes through jets with fine holes to atomize the fuel before it is mixed with air. The carburetor not only atomizes the fuel to ensure a complete mix, but also meters the proper amount of gas - for the amount of air available - to maintain an explosive mixture.

Electrical System and Accessories

If an engine could be started with a hand crank, the only accessories required would be a belt to drive the cooling water pump, and for a gasoline engine,



8-7 Battery Ignition System

an electrical source to fire the spark plugs. The high voltage required to arc across the spark plugs is supplied by either a magneto or a battery ignition system. In either system, low voltage is momentarily converted to high voltage at the proper instant. A magneto utilizes the rotating motion of a flywheel to generate and deliver to the spark plugs at the proper instant a high voltage pulse of electric current.

On outboards with one or two cylinders, a magneto is the electrical source with separate circuits for each plug. Outboards with more cylinders have a more complicated magneto system or a battery ignition system. Large outboards require a starter motor and a battery for power. Some outboards have a generator or alternator to recharge the battery.

Inboard engines have a battery ignition system or a magneto system. The battery supplies current for the spark plugs and also powers the starter motor. A generator or alternator is provided to continually recharge the battery.

Because the cooling, lubrication, and electrical charging functions are so essential to the proper operation of engines, gauges are provided to monitor these functions. Make it a part of your underway routine to periodically check the gauges.

Routine Check List

When preparing to leave the dock, before casting off the lines, check the oil pressure and be sure the cooling water is circulating. If the water is not circulating, determine the cause immediately as overheating may develop and substantial damage could result.

To ensure reliable operation of the engine *after* leaving the dock, the following check list is provided to be used *before* leaving the dock.

1. FUEL. Top off the fuel tank; don't run out of fuel at sea.
2. OIL. Dipstick should indicate oil level is within proper operating range. Don't overfill beyond the top level indicator.
3. HYDRAULIC DRIVE TRANSMISSION. Check the oil level on the dipstick. Again, don't overfill beyond the top level indicator.
4. FAN BELTS. Replace if frayed; tighten if loose. Fan belts should not be too tight as excessive belt and bearing wear may result.
5. WATER. Closed cooling systems - top off or fill to proper level.
6. BATTERIES. Fill with distilled water to proper level. Check to see if they are fully charged. If a hydrometer is available, the cells should be checked for the proper gravity.

7. BILGE BLOWERS. Ventilate at least 5 minutes before starting the engine.
8. ALARM SYSTEMS. There are many alarm systems available for monitoring the items above; however, these systems do not eliminate the need to check the gauges.
9. GREASE CUPS. Keep clean and filled.
10. FILTERS. Keep clean and change at frequency recommended by manufacturer's operating manual.
11. ENGINE. Permit the engine to warm up slowly. Don't get underway with a cold engine. The result may soon be a breakdown of valves, pistons, bearings, etc. It is mandatory that the proper warm-up period be followed so that oil reaches all the moving parts.
12. FUEL PUMP. Some engines are equipped with double diaphragm fuel pumps with a small sight glass indicator. If the sight glass contains fuel, one of the diaphragms has ruptured. The second diaphragm should continue to operate, supplying fuel to the engine, as this is a back-up feature intended for emergency situations. If a ruptured diaphragm is indicated, the fuel pump should be replaced or repaired prior to getting underway.

Inboard Marine Engine Trouble Shooting

THE GOLDEN RULE to follow in locating engine trouble is not to make more than one adjustment at a time, and to attempt to crank the engine after each adjustment is completed. Consider how the engine operates, and attempt to determine the probable cause of any irregular operation, locating the trouble by the process of elimination. Remember that the cause usually is a simple one, rather than a mysterious and complicated one.

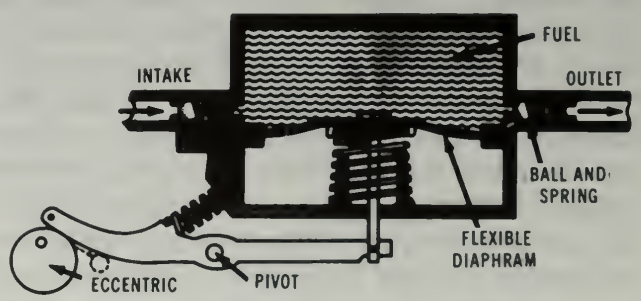
ENGINE WILL NOT TURN OVER - check the battery with a hydrometer or voltmeter. A hydrometer reading of 1.275, or a voltmeter reading of 12-13 volts, will indicate a fully charged battery. If these are not available at the moment, make a test lamp. **DO NOT** short across battery terminals with tools, or solid wire, under any circumstances. A simple test lamp may be made from a double contact 12 volt socket with pigtails or a 110 volt pigtail socket and 25 watt 12 volt bulb. A good battery will produce a bright light. Try to start the engine and observe. If the light does not dim at all, the starter is not being energized. If light goes out instantly, a loose or corroded battery terminal is indicated. If light dims and stays dim after starter switch is released, a weak battery is indicated. **NEVER** do anything that would cause a spark at the battery posts as an explosion could follow by igniting gas that occurs in battery cells under certain conditions.

If the engine doesn't start after the battery has been checked, the trouble may be in the starter switch. Inspect all the electrical connections to ensure that they are tightly secured. Test starter solenoid with a starter jumper, or listen for a clicking sound when starter switch is activated. A test lamp may also be placed across the small terminal and ground of the solenoid. It should light when starter switch is activated. If it does not light, check starter switch by placing a test lamp across the switch terminal and ground. If the test lamp lights, check for broken, loose, or corroded wire between switch and starter solenoid. Check all wiring on solenoid for tightness and condition.

Next, check the Bendix pinion of the starter motor to see if it is jammed. If the pinion is jammed against the flywheel, it may be freed by loosening the bolts which hold the starter motor to the flywheel housing. Reinstall the starter motor and try to start the engine again.

If the battery is supplying sufficient power to the starter and the engine is turning but will not start, then perhaps there is insufficient fuel. Simple; however, lack of fuel is one of the main reasons that most engines won't start - BELIEVE IT OR NOT! If an ample supply of fuel is found, then check the fuel line to make sure that it isn't clogged.

Look at the sediment bowl on the fuel line. It should be filled with gasoline. If it isn't, the fuel line

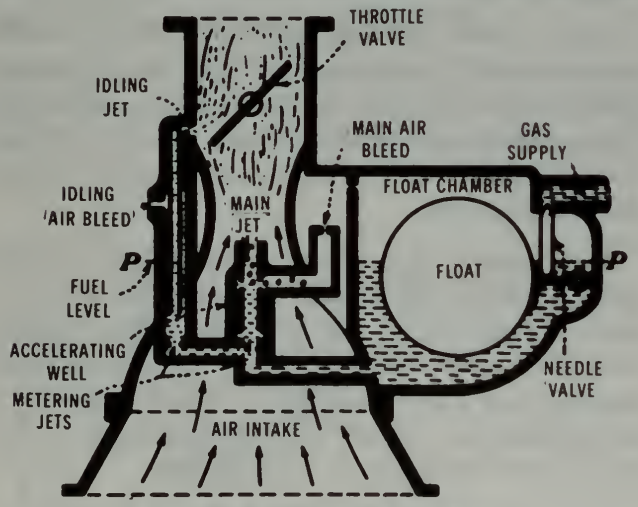


8-8 Gasoline Engine Fuel Pump

or tank vent may be clogged. Or, the valve on the fuel line may have been closed. Check to see if the valve is in the open position. If the valve is in the open position and the fuel line is clogged, disconnect the fuel line at the fuel pump and blow through the line. If the line is clear, then reconnect it to the fuel pump. Extreme precaution should be observed when performing any function which might allow fuel spillage.

Determine whether or not fuel is reaching the carburetor. Remove the sediment bowl (again, be cautious) from the fuel pump. The screen should be clean so that fuel can pass through it. Reconnect the sediment bowl and try the engine again. If your battery is still holding out (along with your patience), make another test.

This test is harder. Remove the spark plugs. Note if they are fouled with deposits and feel them to determine if they are wet. If there is no trace of gasoline in the cylinders and the plugs are dry, the carburetor may be out of adjustment, the float level may be too low, the choke may be inoperative, or



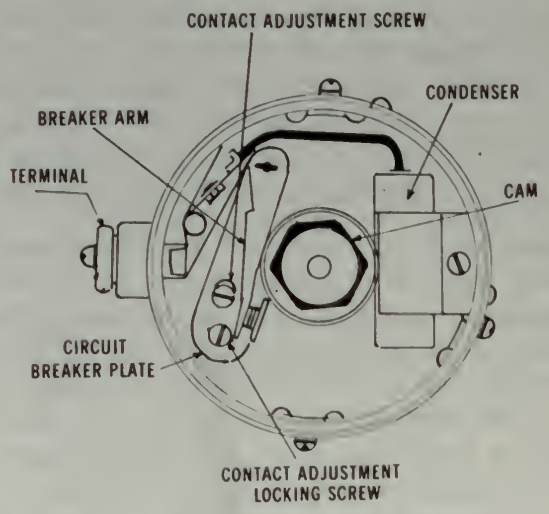
8-9 Float-Type Carburetor

the jets may be clogged with dirt or gum. Clean out the carburetor with "gunk" or "gum-out". Put it back together again and see if it works. However, if the plugs are wet, the engine is flooded. The automatic choke may need adjustment or the manual choke has been left out too long. Dry the engine out by putting the choke in the "OFF" position and opening the throttle wide; then, with the ignition on, turn the engine over several times. Let's hope that this is the final test and the engine starts.

Before the following tests are started, be absolutely sure there are no fumes present. **SAFETY** is of prime importance, and the electric shock hazard, particularly in the normally damp environment of an engine compartment, is extremely dangerous. Some engines are now being equipped with capacitor discharge (C-D) ignition systems which raise the secondary voltage as high as 60,000 volts. Since each lead must be placed a certain distance from the engine block during these tests, it would not be unreasonable to expect one unaware of the dangers to use his hand in positioning and holding the leads. A simple, inexpensive wooden clothespin which may be hand held or clipped to a bracket is one solution to this problem. Since some engines are equipped with C-D ignitions, it should be mentioned that they involve solid state circuits, and correction of a faulty C-D system is best accomplished by replacement of the "black box".

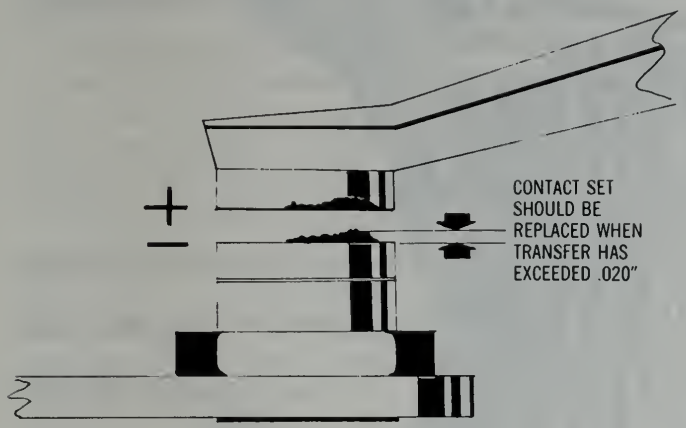
The following tests are for suspected ignition trouble. Ignition trouble is generally suspected when the battery is fully charged and the starter motor is functioning properly but the engine will not start or is running irregularly.

Remove the wire leading from the high tension terminal of the coil to the distributor. Hold the end of the wire 3/16" from the cylinder head, turn the engine over, and test for spark. If there is a weak spark or no spark, the trouble might be in the coil or in the distributor. If the spark from the coil is weak after the distributor has been checked, the coil may be defective.



8-10 Distributor

Examine the distributor cap and the breaker points. Check the breaker points as they may be stuck together or even welded together. In an emergency, these points can be pried apart with a knife or screwdriver. A weak spark or no spark may be caused by a bad condenser which could result in the points being pitted or welded together from arcing. Again, if the points are replaced, the condenser should also be replaced. While the distributor cap is off, examine it to see if any hairline cracks can be detected. If cracks are found, replace the cap with a new one. This is one of the real starting problem areas. Also check the inside of the distributor cap and the rotor for moisture. Dry them out as moisture can cause a short.



8-11 Contact Set

If the distributor and coil are found to be satisfactory, individual spark plugs should be tested. Starting with one cylinder at a time, disconnect the spark plug cable and hold the end of the cable about 3/16" from the cylinder head. Turn the ignition on. A starter jumper may be used if there is no emergency switch. A good strong spark should be evident as the engine turns over. If the spark is good, the plug may be cracked or fouled. Check the plug carefully and, if necessary, replace it.

Outboard Marine Engine Trouble Shooting

There are three basic requirements for an outboard engine to function properly:

1. A correct mixture of fuel and air;
2. Good compression of this mixture; and
3. A good ignition spark.

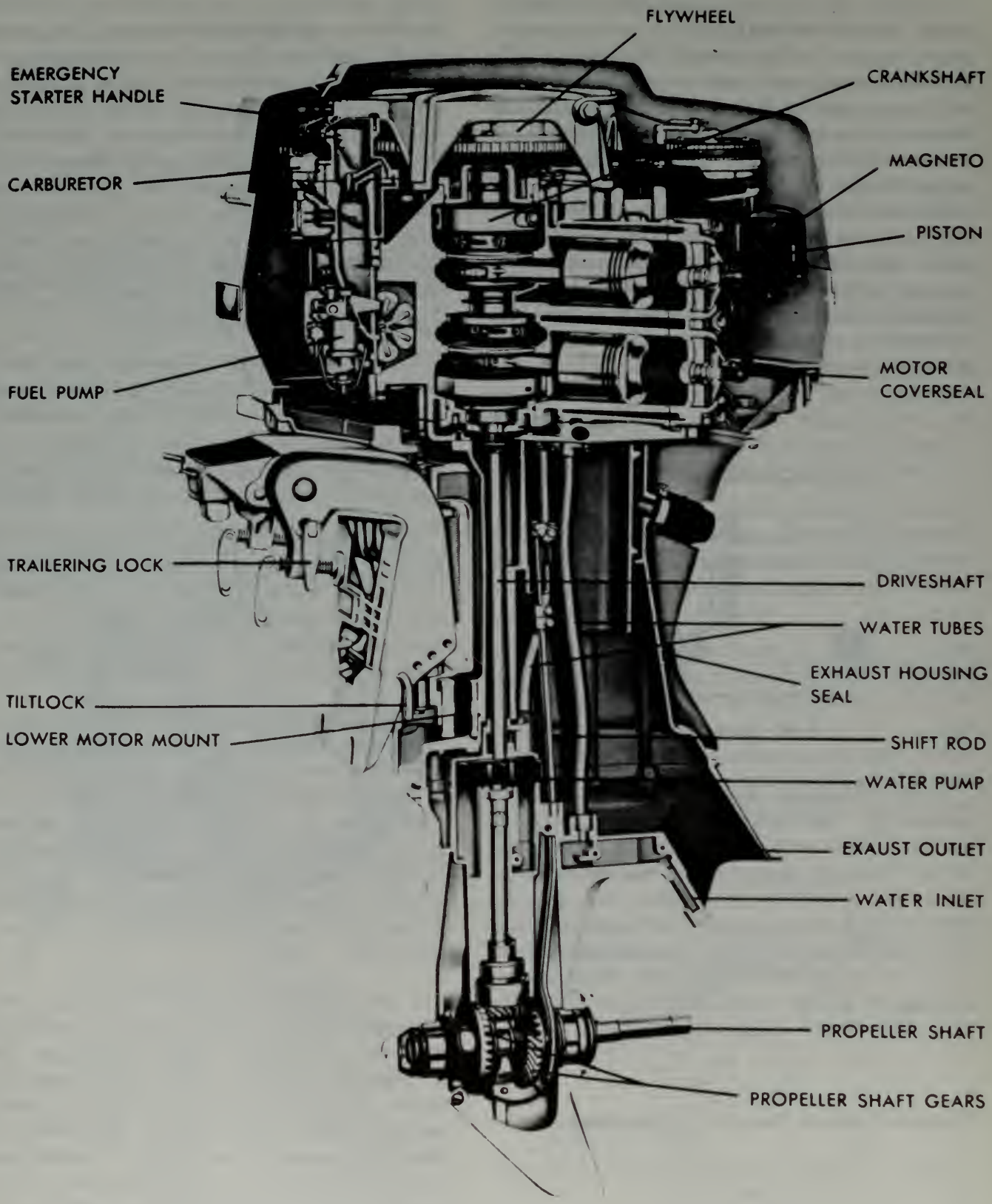
If any one of these is not satisfactory, trouble will result. A correct mixture of fuel and air requires that the fuel must be clean and free from sediment and mixed with oil in the correct proportion. The air vent, shut-off valve, and mixture needle valve must all be opened. Be sure the motor is primed and the carburetor is functioning properly. Rings, bearings, etc., will not be discussed, but check the engine carefully to see if there are any leaking gaskets. Check the coil, distributor, spark plugs, distributor cap, breaker points, and wires carefully. Follow the steps given in the check-off list under "Inboard Marine Engine Trouble Shooting."

Complete each step in sequence and, after each step, try to start the engine. Don't be impatient. Over ninety percent of the problems are simple and can be easily corrected. The problems have been separated into various categories. Determine where the problem is and proceed under that heading.

Fuel or mixture trouble - check the gas tank; is the air vent open? Perhaps the engine is flooded or overprimed, or dirt or water is in the fuel supply; the jets may be plugged up; too much oil is in the gasoline; or, finally, there is a defective fuel pump or hose. Don't forget to try the engine after each test.

Ignition trouble - check to see if wire to the spark plug is disconnected or loose; spark plug wires are crossed; wire to spark plug is short circuited (break in the insulation); spark plug electrodes are fouled with excess oil or moisture; plugs are improperly gapped; plugs have a break or crack in the jacket or insulator; plugs are dirty; breaker points are improperly gapped; breaker points are fouled with oil; or there are broken wires or loose wires to the coil or condenser.

If the engine misses, check for a plug shorting on the motor frame or hood, water or oil on wire terminals or spark plug exterior, or badly deteriorated insulation on the wires. Again, try the engine. If it doesn't start, examine the magneto system. Check the setting on the points; look carefully to see if they are pitted or fouled. If they are, replace the points and the condenser. Don't try to save money by not replacing the condenser. If the points are bad, the odds are that the condenser is also bad. Examine all wires carefully as a broken or cracked wire will short the engine out.



8-12 Sectional View of Outboard Engine

If the engine will not start, thoroughly examine the carburetor. If there is any dirt in the carburetor, it may result in a fuel mixture which is too lean as it approaches the main jet fuel supply passage. Dismantle the carburetor and make sure that the ports are clean, free from dirt, and tight fitting. After checking the carburetor, try starting the engine again.

If the engine will not speed up, it may be overheated. This may be caused by an improper mixture - too rich or too lean - or not enough oil in the gas. Check the operator's manual to determine the correct carburetor settings. Follow the manufacturer's instructions carefully and then attempt to crank the engine again.

If the engine still overheats, one or a combination of the following conditions may exist: the lower unit is not deep enough in the water; the water circulation is obstructed; or the thermostat is defective. Examine the intake opening or the water pipe connections. Check the water inlet and outlet pipes or jackets carefully to see if they may be obstructed with scale or dirt. How about the propeller? Read the specifications in the operator's manual. If the propeller is too large, it will cause the engine to overheat and one that is too small will cause the engine to overspeed.

If the engine knocks, the spark may be advanced too far or it may be the result of using low-grade gasoline in a high compression engine.

If the engine has excessive vibration, one or more cylinders may not be firing. This may be caused by poor ignition or mechanical failure. A bent or fouled propeller, loose mounting bracket, or loose flywheel will have the same effect. If the engine vibrates and ~~e~~mits large amounts of smoke, the trouble may be in the fuel system. Improper fuel mixture or choke operation may be the problem.

Finally, if the engine is hard to turn over, check the oil, determine if the propeller is fouled, or if there are parts that are broken or binding.

Spare Parts and Tools

A lot of time has been spent reviewing trouble shooting. Now you must prepare for an emergency by carrying the proper spare parts and tools with which to follow up on the trouble shooting. There are many marine "service stations" now available for the boatman; however, there is always the chance that something will go wrong while you are in an isolated spot or some place where there is no mechanic available. Therefore, it is a good rule to have aboard a few spare parts and some simple tools. We recommend the following:

PARTS

Inboards	*Outboards*
Spark plugs	Spark plugs
Coil	Starter cord
Fuel filter element and gasket	Shear pins
Fuel pump	Cotter pins
Points and condenser	Propeller
C-D circuit assembly (if applicable)	
Propeller	
Complete distributor or parts	
Generator and starter brushes	
Fuses	
Fan belts	
Spare oil	

TOOLS

Screwdriver	Test light (12 v.)
Adjustable wrench	Feeler gage
Spark plug wrench	Hydrometer
Hammer	Clothespin
Pliers	Rags

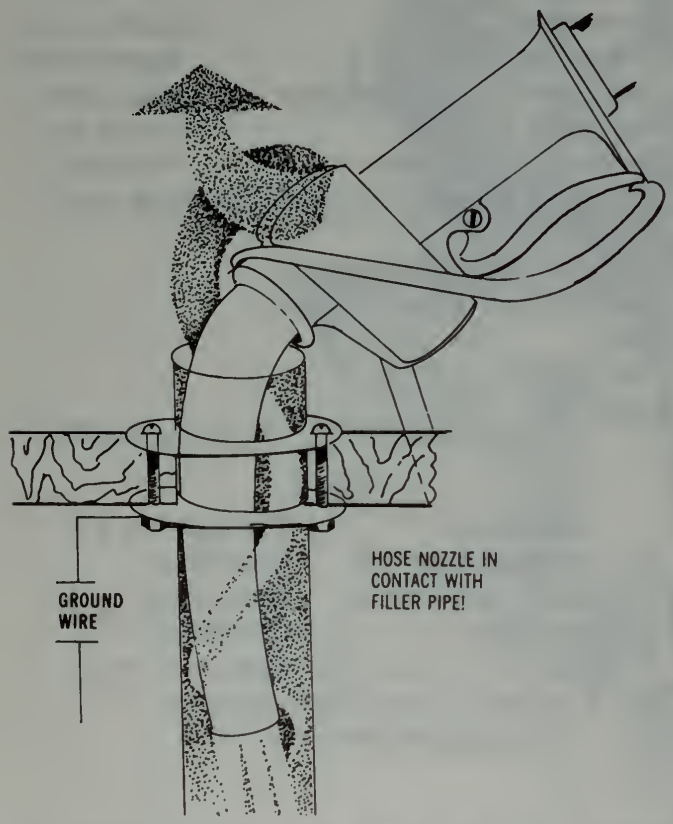
Coat hanger or stiff wire (for cleaning plugged fuel and vent lines)

NOTE: Every boatman should carry operating or manufacturer's manuals for his particular engine and the other equipment aboard.

Fueling

Extremely hazardous conditions exist and are often encountered when fueling. Safety rules should be rigidly observed. When taking on gasoline, all engines should be stopped, galley flames extinguished, hatches, windows and ports secured, and electrical devices shut off. No smoking should be allowed. Diesel fuel, being less flammable, is not as hazardous as gasoline; however, observing the same safety rules is advisable and should contribute to development of "the safety habit."

The gasoline nozzle should contact the filler-pipe deck flange at all times during fueling to prevent the possibility of explosion associated with the discharge of static electricity. (Similar precautions should be observed when fueling tanks used with outboards.) The filler-pipe deck flange should be connected to the boat's ground system. Static electricity is generated internally throughout the length of the gas hose by the motion of gasoline



8-13 Filler-Pipe Deck Flange with Hose Nozzle

and by atmospheric conditions. Modern fuel pump equipment has been designed to prevent this discharge and the danger is, therefore, less than in the past; however, safety precautions are still considered an absolute necessity.

Space should be allowed for fuel expansion; the tank should not be filled to capacity. Approximately five percent should be allowed, based on the average coefficient of fuel expansion. It is not necessary to mathematically compute the fuel expansion; experience can be the controlling factor.

When the fueling operation has been completed, any spillage should be wiped up immediately or washed overboard. Exhaust blowers should be operated for a minimum of five minutes before starting engines. This is sometimes difficult to accomplish when the dock is crowded and other boats are waiting to fuel.

It is important to be thoroughly familiar with the dangers of handling gasoline and the necessary precautions to reduce the risk of fire. Become acquainted with the most effective means of extinguishing a gasoline fire. Gasoline explosions and fires are the leading cause of property damage and one of the significant causes of loss of life and injury on small boats. Gasoline is used as fuel on the majority of boats now in operation, and the boat operator constantly faces the potential hazards of gasoline fire or explosion.

The following Rules for Fueling are reprinted from a publication of the National Fire Protection Association and should be thoroughly learned by every boat operator:

1. Fuel tanks should be properly installed and vented overboard.
2. Fueling should be completed before dark except in emergencies.
3. Whenever a boat is moored at service dock for fueling:
   a. Do not smoke, strike matches or throw switches;
   b. Stop all engines, motors, fans and other devices liable to produce sparks;
   c. Put out all light and galley fires.
4. Before starting to fuel:
   a. See that the boat is moored securely;
   b. Close all ports, windows, doors and hatches;
   c. Ascertain definitely how much additional fuel the tanks will hold.
5. During fueling:
   a. Keep the nozzle of the hose, or can, in contact with the fill opening to guard against possible static spark;
   b. See that no fuel spillage gets into the hull or bilges.

6. After fueling is completed:
   a. Close fill openings tightly;
   b. Wipe up ALL spilled fuel;
   c. Open all ports, windows, doors and hatches;
   d. Permit boat to ventilate for at least five minutes;
   e. See that there is no odor of gasoline in the engine room or below decks before starting machinery or lighting fire. Dangerous vapors will settle to the lowest level of the bilges;
   f. Be prepared to cast off mooring lines as soon as engine starts.

NOTE: Portable fuel tanks should never be filled in the boat. Do this on the dock.

Pre-Season Routine Maintenance — Outboards

1. IGNITION SYSTEM. Go over the spark plugs and points, regap, clean, install, and replace if badly worn or pitted. Check the battery with a hydrometer to ensure that it has a full charge. Clean and inspect the battery cables. Check the polarity before connecting the cables to the terminals. Clean and lubricate electric starter driver mechanisms.
2. LUBE OIL SYSTEM. Remove the oil level plug on the lower unit gear case and check for the proper oil level. If the oil is dirty, change it. Remove and clean fuel filter. Clean the carburetor.
3. METAL SURFACES. Wipe off all surfaces with a clean cloth. Check surfaces for water leaks. When run for the first time, check the operation of the engine's cooling system.

Post-Season Routine Maintenance — Outboards

1. FUEL SYSTEM. With engine operating in fresh water, put oil into the carburetor air intake(s) until the engine starts to smoke heavily. As soon as this happens, stop the engine. Drain the float chamber of the carburetor, remove and clean the fuel filter bowl. Drain and clean the filter elements. Check all gaskets carefully for wear, breaks, or enlarged cutouts. If in doubt, replace the gasket. Empty and clean the fuel tank.
2. IGNITION SYSTEM. Remove the spark plugs; push the throttle all the way to the stop position. Turn the flywheel over a couple of times manually to pump out any residual water in the cooling system. Clean and lubricate the electric starter. It is recommended that the battery be removed and stored in a warm dry place. If possible, hook it up to a battery charger with a slow trickle charge. If the battery is not removed, leave the spark plug terminals disconnected for the winter; this may avoid someone accidently trying to start the engine. Go over the points; if badly worn, replace them. If they are not too badly pitted or worn, then file even, regap, and secure.
3. METAL SURFACES. Wipe all metal surfaces with a lightly oiled rag. This will keep the surfaces from rusting during the winter months. Remove the propeller and lubricate the propeller shaft.
4. LUBRICATION. Drain the lower unit gear case and refill with the lubricant specified by the manufacturer. Consult the owner's manual for other required lubrication.

Pre-Season Routine Maintenance — Inboards

1. FUSE SYSTEMS. Prior to putting the boat in the water, go over the electrical system very carefully. Trace each circuit and develop a wiring diagram. Determine the fuse rating and store several spare fuses of each size in the parts kit. Don't overlook the spare fuses; the fuse box can't be "jury rigged" without taking a chance on starting a fire. Put the wiring diagram in a wax sandwich bag so it won't be ruined by moisture.
2. BREAKER POINTS AND CONDENSER. There are special ignition wrenches that are used to adjust and set the points. These wrenches aren't too expensive and represent a good investment. Before the season starts, check the points carefully for sharp points or

pitting. A fine file is needed to smooth off the points and then regap the points. Don't use emery boards or sandpaper on the points; emory dust or sandpaper dust or grit may contribute to difficulties in the electrical circuit. If the contact points are badly worn, replace the points and the condenser. Using the manufacturer's operating manual, set the proper gap. Then test the engine.

3. SPARK PLUGS. Before the season starts, go over the plugs carefully, clean and regap. Replace if badly worn. Refer to the trouble shooting section and follow instructions.

4. CARBURETOR. If the boat has been laid up for the winter and all fuel was not drained, there may be a gum residue in the carburetor. There are numerous commercial carburetor cleaners in spray cans on the market that will help. Check all parts very carefully. Replace worn or broken gaskets.

5. HOLD-DOWN BOLTS. Go over the base of the engine carefully to determine if any of the bolts are loose. This can result in vibration and cause the engine to run improperly. While checking the hold-down bolts, make sure the bolts on the propeller shaft flange coupling are tight. If the boat has been out of the water, this coupling was probably loosened to avoid strain. Check stuffing boxes for the propeller shaft and rudder post.

6. FLAME ARRESTORS. Clean and inspect the flame arrestors.

7. GENERATOR BELTS. Check the generator belt carefully. If it is frayed or worn, replace it. If loose or too tight, adjust it according to the operator's manual.

8. COOLING SYSTEM. Inspect the water hoses thoroughly. Remove cork plugs and store for use again next winter. Check all clamps; make sure they are tight. Check for leaks. If the hoses are limp or soft, replace them. They may be about to rupture. If water pump is belt-driven, give the belt the same check as generator belt. Check the coolant level in a closed system.

9. BATTERY. Check with a hydrometer to make sure it has the proper specific gravity - that all the cells are good. Clean the terminals and cover with grease. Before connecting the battery cables, check the polarity. The cable lugs and battery terminals are marked (+) and (–) or (POS) and (NEG). Just match them.

10. LUBRICATION. If oil was changed before storage, check the oil level only. If oil was not changed, do so now. Perform all other engine lubrication specified by the manufacturer. Check transmission or gear case for lubricant.

Post-Season Routine Maintenance — Inboards

1. LUBE OIL SYSTEM. Allow the engine to operate in fresh water until it is warm; then drain the oil and replace it with new oil. If the engine has a filter, change and replace it with a new one. Start the engine again and pour engine oil slowly into the carburetor air intake until the engine stalls. Fill all grease cups and lubricate all points specified by the manufacturer.

2. COOLING SYSTEM. Next, drain the water cooling system and, if equipped with a closed system, replace with a half and half mixture of permanent automotive type anti-freeze and water. If raw water cooled, flush with fresh water and drain. Check the water pump carefully for worn gaskets, leaks, cable breaks, worn hoses, etc. Use cork plugs to drive into the exhaust and cooling water lines.

3. IGNITION SYSTEM. Remove the spark plugs. While they are out for cleaning, regapping, or replacing, squirt a little oil into each cylinder and proceed to turn the engine over a few times. Replace the plugs but don't cinch them down tightly. Don't turn the engine over again until next spring. Use the manufacturer's recommended lubricant on the distributor, starter, and generator. Examine the breaker points and condenser. Check the points for pitting or excess wear. Replace if badly worn or, if not worn too

badly, file points until even. As previously mentioned, the points and condenser should be replaced concurrently. Remove the battery and store.

4. FUEL SYSTEM. Drain all fuel from the carburetor and fuel lines. The removal of fuel cuts down the possibility of a fire hazard and the formation of gum or varnish in the fuel system.

5. DRIVE SYSTEM. Drain the transmission and fill it with the proper lubricant. Disconnect the propeller shaft flange. An outdrive gear box should be drained, flushed, and filled with the manufacturer's recommended lubricant.

6. GENERAL. Wipe all the exposed metal surfaces with a lightly oiled rag. This should inhibit rusting during the winter. If the engine has a hood or cover, it should remain on the engine. But don't seal off the engine; it is mandatory that air be allowed to circulate around the engine. Do seal securely the opening at the carburetor intake with strong plastic film or other moisture proof material. On overhead valve engines, remove valve cover and give the entire valve assembly a good oiling.

CHAPTER 9

Marlinspike Seamanship

Introduction

Marlinspike seamanship is the art of handling and working all kinds of fiber, synthetic and wire rope. It includes every variety of knotting, splicing, worming, parceling, serving and fancywork. Marlinspike seamanship has been developed to such an extent that intricate and complicated work in rope can be done to the amazement of the landlubber. Although this is but one of a boatman's skills, excellence in handling line is usually a sign of accomplishment in all fields of boating.

The use of rope aboard vessels has greatly diminished since the days of the clipper ships, but the uses that remain play an important part in the safety of ships and the men who sail them. Think of the damage and injury to a boat and the people on board that could result if the anchor rope were to part on a stormy night because the line had deteriorated through improper stowage. Or, think of the damage that could result if a boat were to be cast adrift during the night because the mooring lines were improperly secured to the cleats. In this chapter, the composition, use and care of rope will be discussed, together with an explanation of some of the more important knots and splices.

Composition of Rope

Rope is manufactured from natural fiber, synthetic materials or wire. Wire rope is little used aboard small craft, therefore this discussion will be confined to natural fiber and synthetic rope. Natural fibers used may be of many types, such as Manila, sisal, hemp, jute, cotton or flax. Of the natural fiber ropes, the best for all around use is Manila. It is used for mooring lines, anchor lines and running rigging such as sheets and halyards. Manila is noted for its strength and durability with a minimum of stretch.

Since Manila fiber is obtained mainly from the Philippine Islands, it is more expensive than many other fibers. A more readily available fiber, sisal, is widely used in place of Manila, although it is inferior to Manila in many ways. The other fibers are used mostly for small lines, lead lines and flag halyards. In recent years, many boatmen have switched from the use of natural fibers to rope manufactured from synthetic materials. These synthetics include nylon, dacron, polyethylene and polypropylene.

Size-for-size, nylon and dacron rope are much stronger than comparable size Manila rope. For this reason, you can use smaller diameter rope in nylon or dacron than can be used in Manila to get the same strength. Both types can be stored when wet without any loss of strength. Nylon and dacron are also resistant to rot, mildew, sunlight and salt water. The use of nylon is desired when strength and stretch go together, such as mooring lines and pendants, anchor lines, towing lines and spring lines. Nylon elongates about 10% at normal working loads, and over 40% up to its breaking strength.

Strength Tables

In the table shown, the weight and strength of the three most popular ropes are listed according to their diameter. In each case, the weight is approximate and the breaking strength is conservative. One should keep in mind that "breaking strength" loads should never be applied deliberately to any rope. Yachtsmen use a safety factor of 5 to 1 to provide maximum safety where lives and property

are at stake. To be on the safe side, you should use a rope with a rated breaking strength of FIVE TIMES THE WEIGHT which you intend to lift or pull.

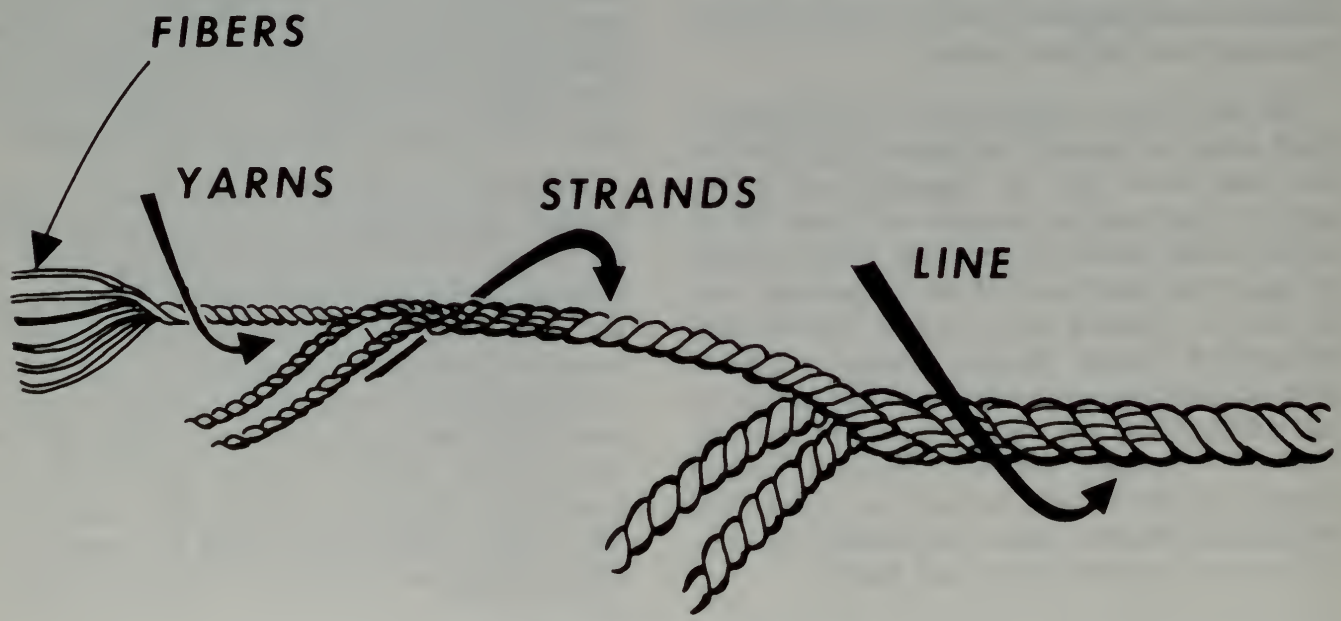
YACHTING ROPES – WEIGHT AND STRENGTH COMPARISON

SIZE Diameter	NYLON (lbs) Weight per 100 ft	lbs Breaking Strength	"DACRON" (lbs) Weight per 100 ft	Lbs Breaking Strength	MANILA (lbs) Weight per 100 ft	Lbs Breaking Strength
¼"	1.7	1,750	2.2	1,300	2.0	600
⅜"	3.5	3,200	4.5	2,850	4.0	1,350
½"	6.6	6,600	7.6	4,900	6.1	2,650
⅝"	10.5	10,200	12.4	7,800	13.1	4,400
¾"	15.0	13,500	19.3	10,780	16.3	5,400
⅞"	20.5	18,500	23.5	14,000	22.0	7,700
1"	27.0	24,000	31.3	17,500	26.5	9,000
1⅛"	34.5	32,000	40.4	23,500	35.2	12,000

Polyethylene and polypropylene ropes have become more and more popular with boatmen. They are characterized by exceptionally good strength both wet and dry, low elasticity and strong resistance to acids, alkalis, water, mildew and rot. Polypropylene is used often as a water-ski tow rope because it floats on the water.

How Rope is Made and Measured

In the manufacture of rope, the fibers are twisted together in one direction to form yarns, and the yarns are twisted together in the opposite direction to form strands. The strands are then twisted together in the original direction to form the finished rope. Occasionally, cable rope will be made, which consists of three or four ropes twisted together in the opposite direction. The final direction of the rope is known as the lay of the rope, and is described as either right-laid or left-laid.



9-1 Composition of a Line

The general term for cordage is *rope*. It becomes line only when it is put to use on a boat. However, there are a few exceptions where it is in use on a vessel and is still called rope. Such variances include bell ropes, bolt ropes, man ropes and dip ropes, among others. To call a sailor's mooring lines "ropes" is to immediately brand yourself as a landlubber of the worst order.

Fiber rope is correctly measured by its circumference. However, most marine suppliers prefer to measure it by its diameter. Most pleasure boatmen have also followed this practice. On the other hand, wire rope is always measured by its diameter. Small diameter fiber rope is known as small stuff, and is designated by size according to the number of yarns it contains. Yarns are called threads when referring

to small stuff. For example, 6 thread small stuff is made up of six yarns of fiber twisted together. Small stuff is frequently used for seizing when whipping line.

Care of Fiber Line

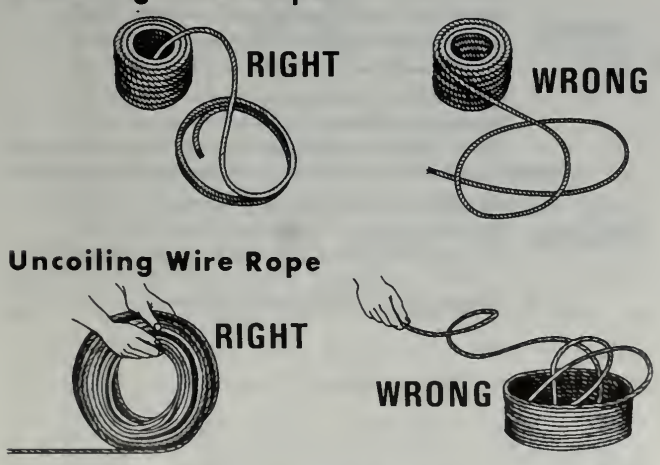
Your efforts in caring for fiber line aboard your boat will be repaid in greater safety and longer life. Whenever natural fiber rope is uncoiled from a new coil or when a quantity of rope is taken off a coil, there is a procedure you can follow that will avoid making kinks in the rope. The coil is placed upright so that the end of the rope inside the hole in the coil is at the bottom of the hole. The end is then taken up through the hole and the desired quantity of rope is drawn off. New synthetic fiber rope is handled in a different manner. Normally, synthetic rope is received on a reel and should be rolled off, not uncoiled. If these procedures are not followed, there will be a kink in the rope for each turn taken off the coil or reel. Kinks should always be taken out of a rope whenever they occur. By putting a strain on the rope, a kink can be made to disappear but the rope will be badly weakened by the breaking down of the fibers at the point where the kink occurred.

For easy, seaman-like handling, each length of rope should be taped temporarily at both ends with marine tape when cut from the original coil or reel and permanently whipped with nylon whipping cord at the earliest opportunity.

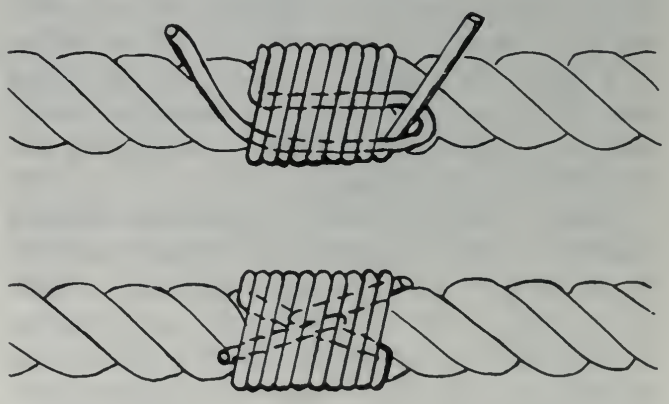
Rope that is not being used should be stowed in a dry well-ventilated place to prevent accumulation of moisture and resultant rot. Lines should be stowed on shelves or gratings off the deck and other material should not be stowed on top of them. Natural fiber lines are most susceptible to damage from moisture. Manila line, for instance, should be washed off with fresh water after salt water use and thoroughly dried before being stowed. Synthetic fiber lines such as nylon may be stowed when wet but this practice introduces unpleasant dampness below. All lines should be kept away from exhaust pipes and battery acids.

A fiber line should never be overworked or overstrained. Although it may not show it, the line may be seriously weakened due to breakdown of the fibers. A good way of checking for deterioration of a line is to look at the inside of the line. If there is a noticeable accumulation of grayish powdery material the line should be replaced. Another indication is a decrease in the diameter of a weakened line. Natural fiber lines will contract if they become wet or damp. A line secured at both ends will become taut during rainy weather and may become badly overstrained unless the line is loosened. This is particularly true of mooring lines and flag halyards, which should be slacked off if they become taut because of rain or dampness. It is good practice to wrap your mooring lines with canvas chafing gear where they pass through the chocks. Anchor line, too, should be protected from chafing and rubbing.

To obtain the maximum use of a line and at the same time maintain safety, it is a good idea to turn a line end-for-end periodically. Anchor ropes or boat falls, where one end of the line usually has all the strain put on it, are good examples of lines



9-2 Uncoiling Rope



9-3 Temporary Whipping

which should be reversed from time to time. Never leave the end of a line dangling loose without a whipping to prevent it from unlaying. Unless protected, it will begin to unlay of its own accord. To prevent fraying, a temporary plain whipping can be put on with anything, even a rope yarn or a piece of friction tape.

Making Up Line

All line on board your boat should be stowed neatly when not in use. How you stow the line depends on its ultimate use. There are three methods of making up line—coiling, faking and flemishing. Line that is to be stowed in a compartment or locker should be coiled and made up, or stopped off with small stuff. Right-laid rope should be coiled right-handed (clockwise) and left-laid rope should be coiled left-handed (counterclockwise).

9-4 Line Ready for Stowing

Lines that are made up for a fast runoff such as mooring lines, heaving lines, and running rigging, may be faked down if there is sufficient room. Faking down consists of laying the line in coils either in a figure eight fashion or with each fake lying clear of the next. Faking down leaves the line in the most advantageous position for running out without fouling or kinking.

Some boatmen like to leave their line on the deck when not in use. To give it a neat, ornamental look, it can be flemished. The line is laid on the deck like a spring, each coil circling the one preceding it. Right-laid line should be coiled clockwise, and left-laid line should be coiled counterclockwise. To tighten the coils when you are finished, lay both hands flat on the line at the center and twist in the direction the coils are laid, thus forming a tight mat. It should be noted here that a beautifully flemished line should not be left on a varnished surface for any length of time, especially overnight. The trapped moisture will spoil a good varnished finish.

Knots, Bends and Hitches

Among boatmen, the landsman's all-inclusive term "knot" gives way to provide more specific meaning, and includes bends and hitches. Each knot, bend or hitch serves best in a particular circumstance and is practically worthless in other situations. To meet your needs a good knot must display certain characteristics. It must hold well without slipping. If it is to be used for practical purposes and not serve as an ornament, it should be easy to tie. The superior knot is one that possesses these advantages and is easy to untie as well.

Most of the knots, bends and hitches that you will need to know in the normal operation of your craft are listed and illustrated below. While we could have added many more, they would seldom be used. It is far better to have a good knowledge of a few commonly used knots than to have a superficial knowledge of a great number of seldom used knots. Those illustrated here are functional, will serve almost every purpose, and are as easy to untie as they are to tie.

How Knots and Splices reduce strength of rope

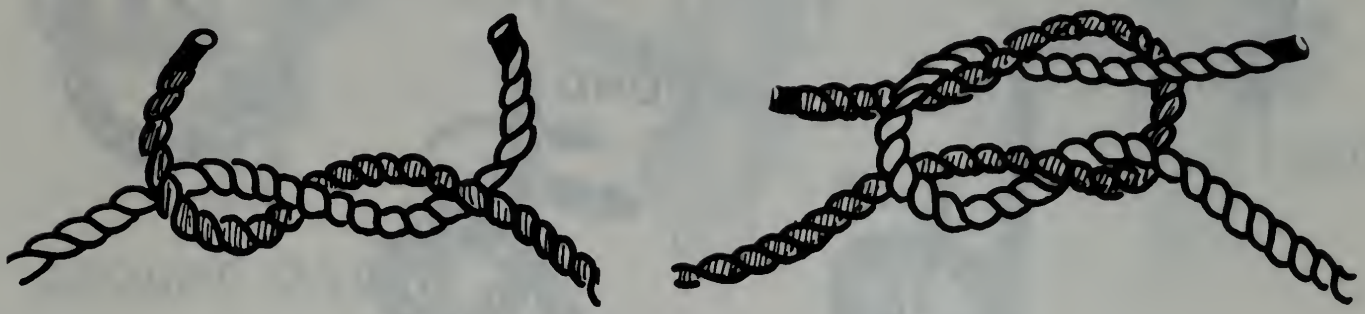
		%EFF
KNOTS	Normal rope	100%
	Anchor or Fisherman's bend	76
	Timber hitch	70-65
	Round turn	70-65
	Two half-hitches	70-65
	Bowline	60
	Clove hitch	60
	Sheet bend or Weaver's knot	55
	Square or Reef knot	45
SPLICES	Eye splice (over thimble)	95-90
	Long splice	87
	Short splice	85

9-5 Strength of Different Knots

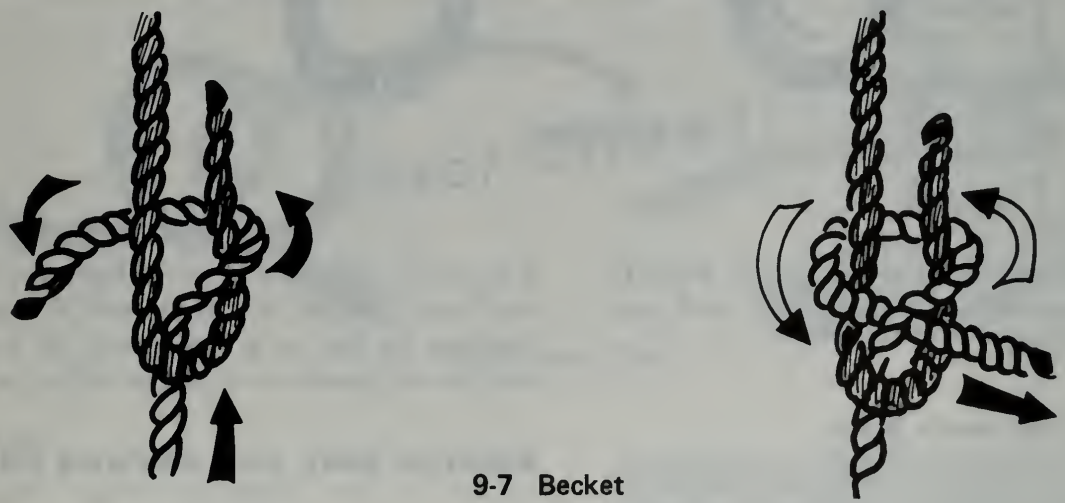
Square Knot (Reef Knot)

The square knot, also called the reef knot, is used to join lines of equal diameter together. It

should never be used to join unequal lines as it will slip. The square knot is employed for a multitude of purposes, and is so versatile on boats that it is sometimes referred to as the sailor's knot. We should, however, include the caution that the square knot should not be used to tie lines which will be subjected to heavy loads. The square knot has a serious disadvantage in that it will "tumble" when placed under heavy strain and, in this condition, is almost impossible to untie.



9-6 Square Knot



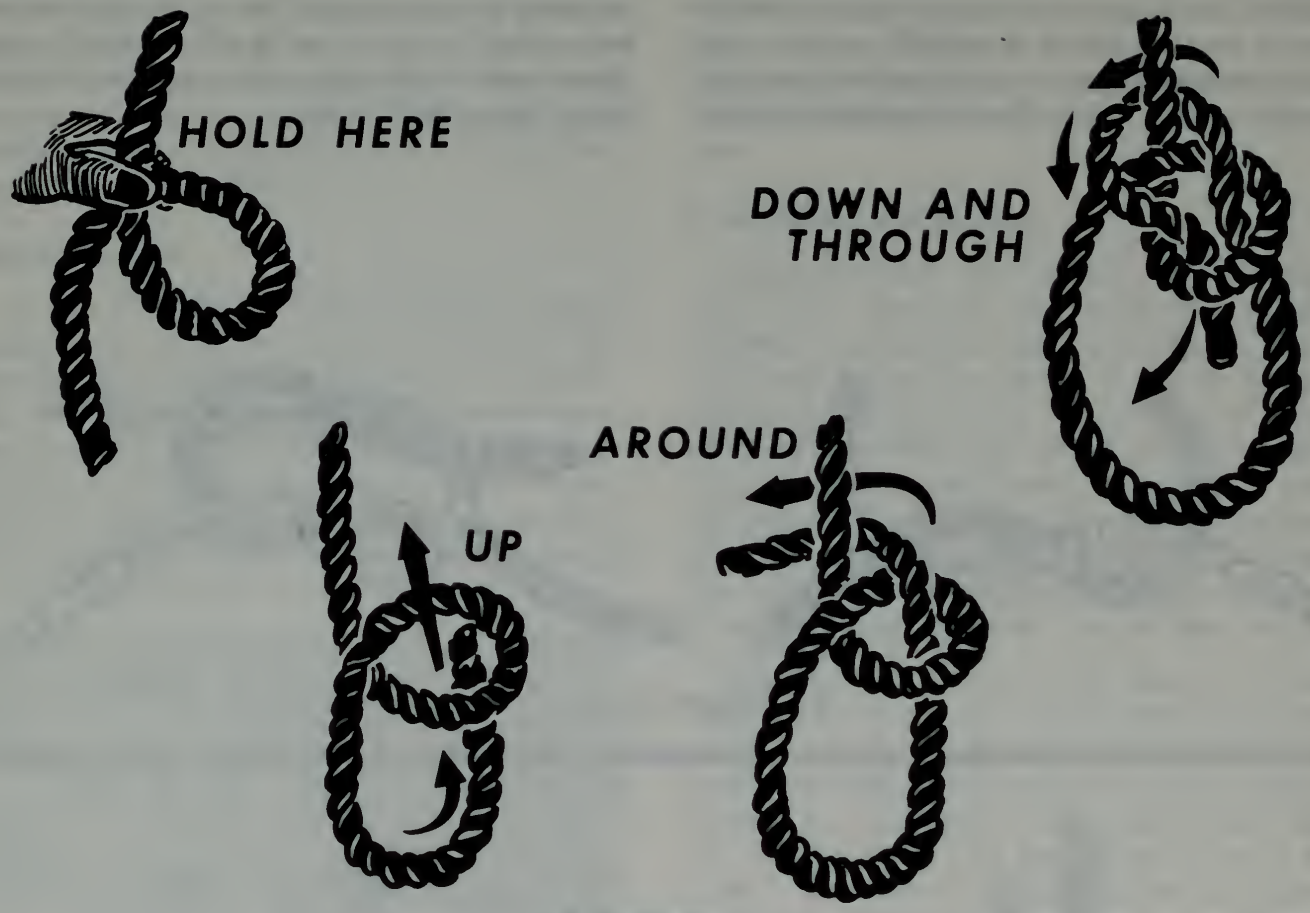
9-7 Becket

Sheet Bend (Becket Bend)

The sheet bend, also known as the becket bend, is used for tying two lines together. This bend will securely hold two lines together even if the lines are of unequal sizes. It is comparatively easy to untie even after having been subjected to heavy strain for long periods of time. When used on a tow line, the free ends should be stopped down with twine for maximum security. The lighter line should be "bent" around the heavier line. An extra turn can be taken around the heavier line for extra security. When this is done, the bend is known as a double sheet bend, or double becket bend. The double sheet bend is also suitable for attaching a line to an eye.

Clove Hitch

The clove hitch is used to tie a line temporarily to a pile or bollard. It is easy to tie and is reasonably secure for short periods of time. Many boat-



9-8 Bowline

men make doubly sure by adding a half hitch to the standing part. When wet, the clove hitch may be difficult to untie.

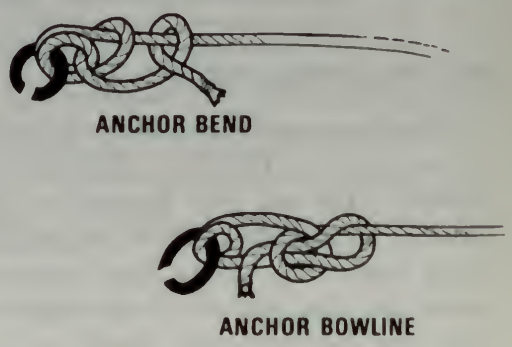
Anchor Bend (Fisherman's Bend)

The anchor bend, also called the fisherman's bend, is simple to tie and is extremely strong. It will not slip or jamb and is easily untied, even if it has been subjected to a great strain. It is used to tie a line to an anchor ring, a buoy or a spar. To prevent the bend from working loose, a second half-hitch is sometimes taken around the standing part, or the end is seized back to the line with small stuff.

Bowline

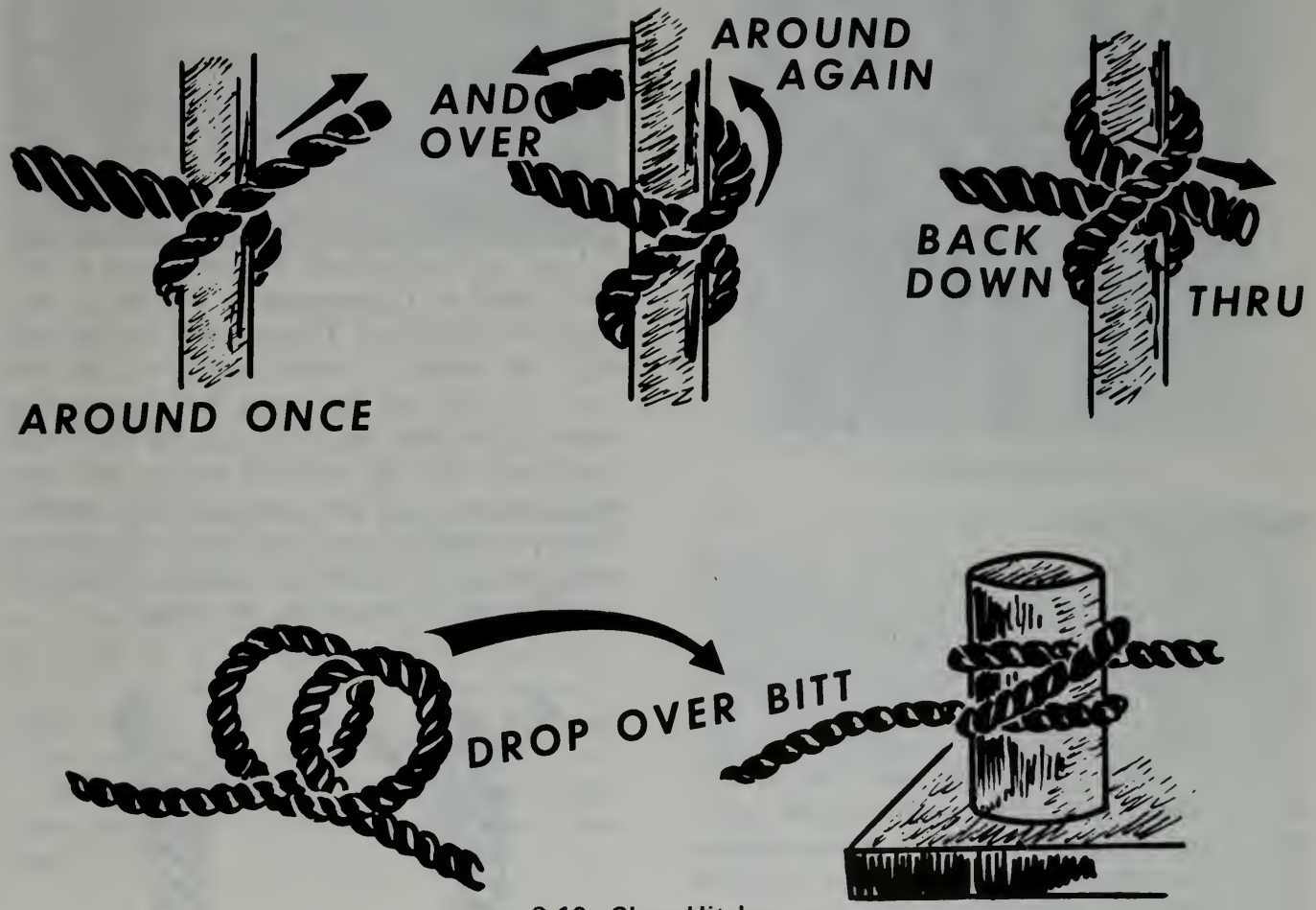
The bowline is known as the king of knots because it is easy to tie, will not slip nor jam, and is as easy to untie as it is to tie. Basically, the bowline forms a secure loop at the end of a line. This loop can be used in a wide variety of ways. The loop can be placed over a post or bollard as a moor-

ANCHOR BEND AND ANCHOR BOWLINE



9-9 Anchor Bend and Anchor Bowline

ing line. It can be used to tie to an anchor ring. Heavy lines are often tied together by using a bowline on the end of each line, with the loops passing through each other. By passing the standing part of the line through the loop, a free running noose can be made. A bowline, properly tied, will not slip, nor does it pinch or kink the line as much as many other knots.



9-10 Clove Hitch

Figure Eight

The figure eight is principally used as a stopper knot. It is placed at the end of a line to keep it from running through a block or other opening. The figure eight can also be used temporarily in place of whipping to keep a line from unraveling.

9-11 Figure Eight Knot

Two Half-hitches

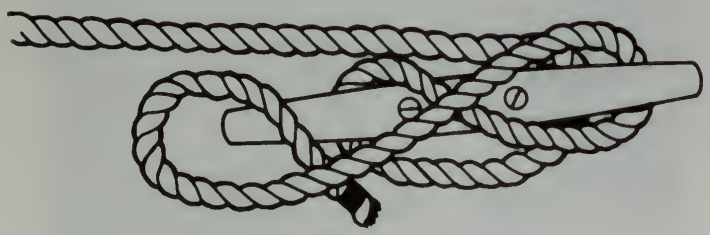
Two half-hitches are very easy to tie and are used most often to secure a line to a ring, spar, post or bollard. This hitch is not as popular as the clove hitch although it displays approximately the same characteristics. It is more easily untied than the

clove hitch. Note that this knot consists of a turn around the fixed object and a clove hitch over the standing part of the line. Two half-hitches are better than a clove hitch when permanence is desired.

9-12 Two Half Hitches

Belaying a Cleat

Securing a line to a cleat is one of the most common procedures in docking a boat and yet it is frequently done improperly. The correct method is to lead the line in one round turn around the base of the cleat and then to form at least one figure eight around the horns of the cleat. Secure the line with a half-hitch over one horn of the cleat. One caution - be sure to have the line figure-eighting over the cleat when the half-hitch is made. Do not make the error of having the last loop come along the side of the cleat instead of crossing over. This fastening may also be referred to as a "half-hitch on a cleat" or as a "cleat-hitch".



9-13 Belaying a Cleat

Splices

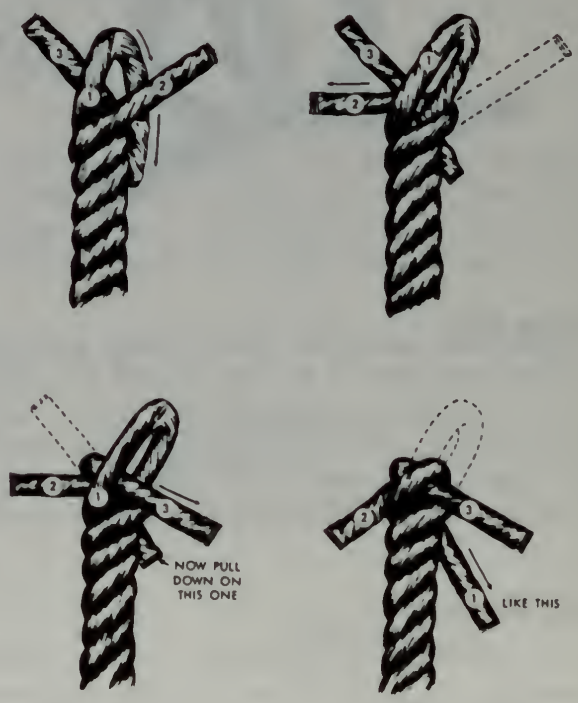
Splices are used for permanently joining or marrying two lines together, making a loop in the end of a line, or finishing off the end of a line.

The Back Splice

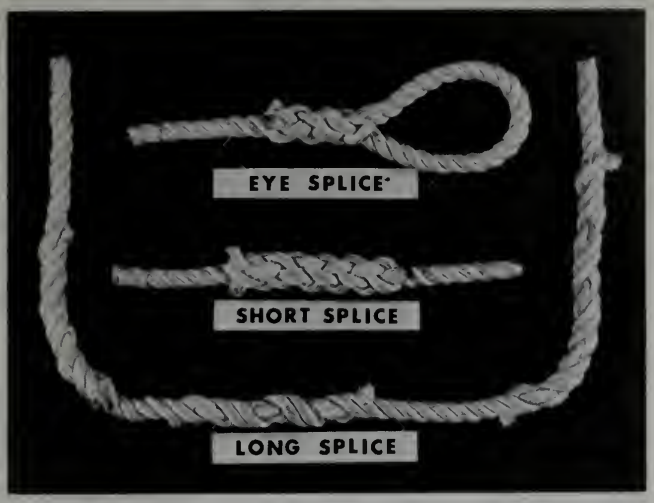
When a line has been cut, a back splice can be woven into the end to prevent unraveling. The back splice is started with a crown knot, and finished off by tucking the left-over strands over and under the strands in the main part of the line. Be sure to burn the ends of each strand of synthetic rope before attempting any splicing to prevent unraveling of the ends. It is also a good idea to whip the ends of strands of manila or other natural fiber ropes for the same reason.

The Short Splice

Lines are short-spliced together when a slight enlargement of the diameter of the line is not a matter of importance. The only trick in short splicing is in seizing the ends together so that each strand in one end lies along the corresponding strand in the other end. After unlaying the strands, you simply butt the two ends against each other until you see that they are interlaced correctly. Once your seizing is on, tuck over and under the same way you finish off an eyesplice. Three tucks on either side of the seizing are enough.



9-14 Crown Knot

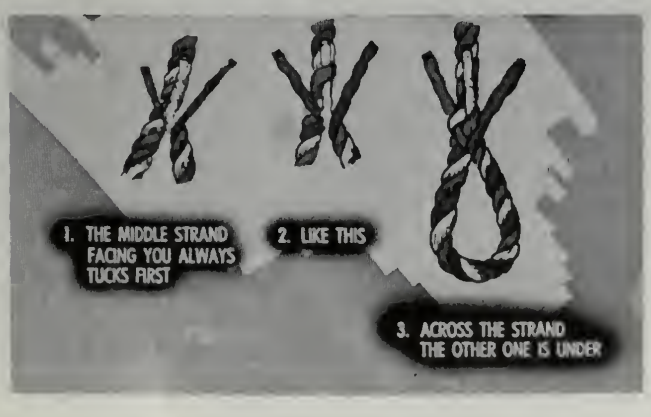


9-15 Eye Splice

The Eye Splice

When a permanent loop in the end of a line is desired, such as a mooring line, an eyesplice is used. To make an eyesplice, unlay the strands of the line and splice them into the standing part of the line by tucking the unlaid strands from the end of the line into the standing part. An original round of tucks plus two more complete rounds is enough for any ordinary eye splice in natural fiber line such as Manila. An extra tuck should be made when splicing nylon line because of its smoothness and stretch.

Illustration 9-16 shows the proper steps in making an eye splice.



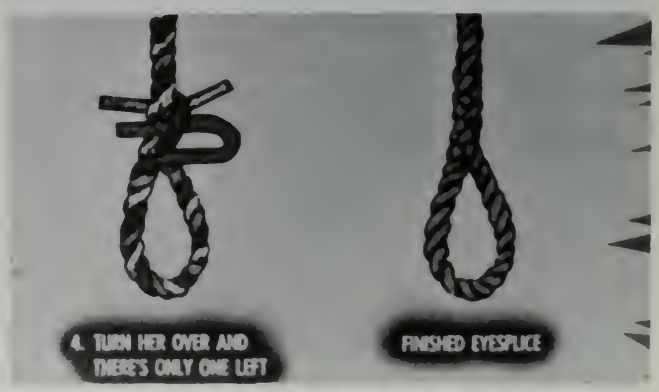
The Lead Line

A lead line is a line which has been marked in such a manner that it can be used to measure the depth of the water. The line is weighted with a "lead" which should weigh at least five pounds for depths of 100 feet. Ideally, the line should be braided cotton, 150 to 200 feet long. Seamen have a system of marking the line with strips of leather or cloth, or by knots. These markings are as follows:

2 fathoms	2 strips of leather
3 fathoms	3 strips of leather
5 fathoms	strip of white cottonrag
7 fathoms	strip of red woolen rag
10 fathoms	strip of leather with a hole in it
13 fathoms	same as 3 fathoms
15 fathoms	same as 5 fathoms
17 fathoms	same as 7 fathoms
20 fathoms	2 knots
25 fathoms	1 knot
30 fathoms	3 knots
35 fathoms	1 knot
40 fathoms	4 knots
	(and so on)

These markings are not in widespread use among recreational boatmen. Any markings used should be easily remembered and able to be read quickly. It is for this reason that many marine dealers feature lead lines with plastic strips attached, on which the depth is marked in easy-to-read figures. These lead lines require no memorizing of marks and are marked in single fathoms up to ten fathoms.

In practice, the lead is cast forward with an underhand swing while the boat is proceeding under very slow headway. The speed should be slow enough that the lead will reach the bottom by the time the line stands vertically. The vertical distance from the waterline to the hand of the person casting the lead should be known. The mark which is



9-16 Making an Eye Splice

held in the hand is read and the distance to the water is deducted from this figure.

9-17 Lead Line

The Armed Lead

Some leads have a hollowed-out portion on the bottom of the lead which can be "armed" with a quantity of tallow or bedding compound. In a pinch, a wad of chewing gum can be used although you may have difficulty in getting it to stick to the lead. Using this procedure, a sample of the bottom can be brought up. In most cases the character of the bottom is shown on your chart. By having a sample of the bottom, you may be able to further identify your position, especially in conditions of reduced visibility when no landmarks are in sight.

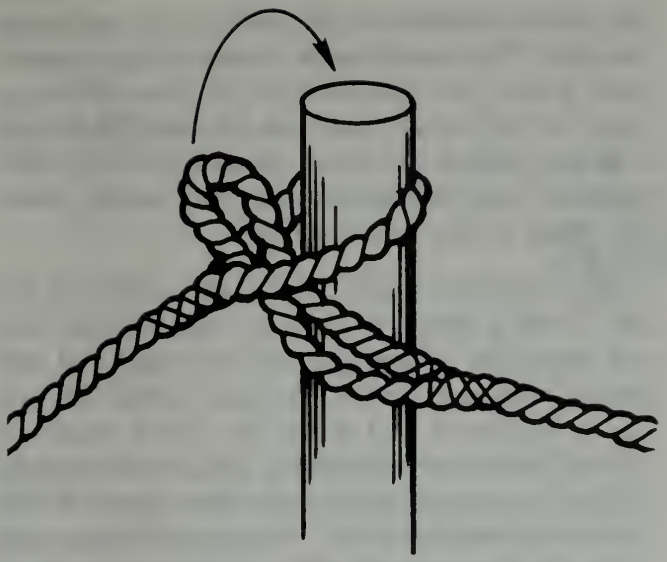
The Heaving Line

On small craft, a heaving line will seldom be used. Nevertheless, the well found boat will always have a heaving line aboard. A heaving line is made up of a small line (50 to 60 ft long) with a weight at one end. This weight can be a "monkey's fist" (an intricate woven knot which surrounds a weight), a soft rubber ball which has been drilled and the end of the line pulled through it, or a small chamois or canvas sand bag. The purpose of the weight is to enable the end of the heaving line to be heaved out to its full length. A heaving line is not a weapon, although, if not carefully used, it can sometimes cause as much damage as a weapon. It is for this reason that the weight should not be any heavier than necessary to carry the line out to its full length. The heaving line is made up in loose coils, arranged for free running. The line is carried in both hands with approximately half of the line in each hand. It is thrown with a strong underhand swing.

In practice the heaving line is used as a messenger to send a heavier line ashore or to another boat. It is seldom necessary to use a heaving line when approaching a pier or float. There may be instances when circumstances will not permit a boat to approach a pier close enough to heave a mooring line ashore. In these cases the necessary extra distance can generally be spanned by using a heaving line. On small craft the heaving line is most often used when passing a line from one boat to another when sea conditions make a close approach dangerous. The heaving line is heaved *over* the deck of the other craft. The weighted end of the heaving line should splash into the water on the far side of the other boat. All too many heaving lines have been thrown through the windshield or through the side window of other craft. This is not only dangerous but it seldom, if ever, favorably impresses the owner of the other boat. Do not attempt to cast a heaving line directly at another person. It could strike him and injure him although, if thrown directly at another person, it will generally fall short. To repeat, heave the line completely over the other boat. In this way it will not matter if it is thrown too far, and it will be relatively simple for the operator of the other boat to grasp.

Dipping the Eye

Sometimes two lines, with eye splices, are to be placed on one bollard. If the two eyes are simply dropped over the bollard, it may not be possible to remove the first line until the second one has been taken off. To avoid this problem, bring the end of the eye of the second line up through the eye of the first line and then drop it over the bollard. By doing this either line may be removed first with no problem developing.



9-18 Dipping the Eye

Tow Lines

It is a tradition among seamen that a vessel in distress is not left to fend for herself. If you encounter a vessel in trouble afloat, you are morally bound to render all possible assistance without placing your boat or your crew in danger by doing so. This assistance may be limited to standing by until other help arrives but, in most cases, it involves towing the other boat to a safe mooring or anchorage.

The business of towing another boat is relatively simple if a few precautions are observed. The often-heard statement that you should insist on using the other fellow's towline is absurd. "Sea lawyers" who insist on using a towline of unknown capabilities are generally asking for trouble. You know (or should know) the condition of your lines, and you are usually well advised to use equipment you can trust. Remember that *when you take another boat in tow you assume full responsibility for this boat and all hands aboard.* If, as the result of your "assistance," the other boat is left in worse condition than it was before you touched it, you could be held legally liable. For this reason, it is simply not wise to ever tie a line to a sinking boat. Take the persons off but don't tie a line to it. If this boat sinks on the end of your towline, you might not be held responsible, but then again, you might be.

Towing equipment consists of a towline, a bridle, a short length of smaller line, and a heaving line. A bridle is a short line (usually three times the width of your transom) with an eye splice on both ends. If possible, the bridle should be attached to the boat forward of the rudder post. In practice, the eyes of the bridle are generally placed over the stern cleats. The towline is made fast to the bridle. This centers the tow and makes it much easier to control.

The diameter of line used for the bridle will depend on what your cleats can accommodate. Needless to say, the cleats should be sturdy enough to handle a considerable strain without breaking or pulling out from the deck. If you doubt the strength of your cleats, don't use them for towing. Attach the line to something you can trust.

The size of the towline will depend on a variety of conditions. Your choice is limited to what you have aboard. If you doubt the ability of a line to handle a tow, don't use it. Sea conditions and the weight of the distressed vessel are most important.

9-19 A Towing Bridle

On many small boats, the cleats and chocks are small in size and are often attached with screws without a doubler under the deck. In these circumstances, it is possible to pull out the cleats, chocks or part of the deck. If the stem ring is bolted through (not merely installed with screws), it can often be used for towing, although in some cases the ring will not stand the strain of a long tow. If you are suspicious about the condition of the cleats or stem ring on the distressed vessel, it might be well to go aboard (with their permission) and inspect these items personally. In extreme cases, it may be necessary to pass a sling completely around the other boat, with the towline attached to the sling.

A towline should be in excellent condition and large enough for the task. If you have a choice, always use the heavier line for additional safety. If the towline is too large for the cleat of the towed vessel, double up a smaller line and attach it to the end of the towline.

A nylon towline is preferred over Manila because of its higher strength and shock-absorbing elasticity. However, a word of caution concerning towlines should be inserted at this point. All lines have a rated breaking strength and will part suddenly when over-strained. If a towline parts under strain it can snap back in either direction like a whip. Because of the elasticity of nylon line, this potential danger is greater with a nylon towline than with Manila. The towline should never be over-strained deliberately, and it is good practice to keep persons clear of the stern when you have another boat in tow. This is also true of the towed boat, and persons should be advised to keep clear of the towline on the bow.

Towing

While towing, keep the boats far enough apart to allow the towline to assume a long smooth curve which can act as a spring. Adjust the length of the towline so that both boats are climbing and descending waves together. Unless this is done, the line will be alternately slack and taut, which severely strains the line. If the towed boat is descending while the towing boat is climbing a wave, the tow-line will come up with a dangerous snap when the relative positions of the boats on the waves are reversed. This condition is almost always present when towing in a following sea. In some following seas, the only way a boat can be towed is to trail a drogue behind the towed vessel which will offer sufficient drag to keep the tow from surfing down the waves of the following sea.

Most boatmen make the mistake of towing too fast. Towing should be done at a speed which will not strain the towing gear or fastenings and still permit complete control. In many cases, the rudder of the towed boat should be placed amidships and tied down in this position since most attempts to steer a tow do more harm than good. If the towed boat begins to yaw (swinging from one side to another on the towline) it could easily capsize. Yawing *must* be stopped as soon as it develops. This can usually be controlled by either trimming the towed boat well aft by moving as much weight as possible toward the stern or trailing a good sized drogue behind the towed boat. In some cases, it will be necessary to trim the towed boat aft and rig a drogue in order to control the tendency of the tow to yaw.

Once you get the tow into sheltered waters of a marina or harbor, you should slow down and shorten up the towline. Most powerboat operators in trouble claim "engine failure" as the cause of their problem. It's amazing how often a few gallons of fuel will "cure" their troubles. Your responsibility for this tow ends when you have her safely tied to a pier or float, so your best bet is to head for the nearest fuel float. Come up to the float slowly and have one of your crew simply step off with the towline in hand. Standing on the float, he can pull the towed boat in hand-over-hand. Unless you have experience in landing with a boat in tow, do not try to be too fancy in making your landing. The method described may not impress onlookers but it will do the job with the least amount of fuss. Additionally, it is guaranteed to work—every time!

CHAPTER 10

Sailing

Large or small, old or new, simple or complicated — all sailboats respond in the same basic ways to the forces of wind and water. By learning the principles of sailing, you can take a giant step toward handling any sailboat with skill and safety. The information presented here is, however, only an introduction to the sport of sailing: Having mastered it, you'll still be a beginning sailor.

As a novice skipper, you'll be well advised to continue your sailing education, both on the water and in the classroom. By all means go sailing — it's the best way to improve your skills, the best way to put principles and theory into practical use. But bear in mind that, at this stage, you should be extra careful. Following these simple rules will help you get the most fun from sailing:

1. Always check the weather before setting out: Get a *marine* weather forecast that's up to date. If bad or even unsettled weather is predicted, don't go — there'll be another day.

2. Never sail alone: Like skindiving solo, sailing single-handed exposes you to extra hazards and difficulties. If possible, crew for a more experienced sailor; don't be afraid to ask him or her what's going on, if you don't understand. If you sail with another beginner, take turns steering and handling the sails.

3. Select a proper boat: You can learn to sail in virtually any kind of craft, but some boats are better for learning than others. The ideal boat for most beginners is a single-masted vessel of 16-20 feet in length (assuming a crew of two or three). It should have a place to stow safety and other gear (often under the forward deck), and it should be equipped with built-in flotation, so that in case of capsize or swamping it'll stay afloat and support the crew as well.

10 - 1 Offshore Cruiser-racer

10 - 2 Daysailer

4. Make sure your boat is properly equipped. The average daysailer (boat without a cabin) needs little gear, and here are the essentials: Coast Guard-approved personal flotation device for each person aboard (a buoyant vest will do, but if you're serious about your sailing, consider one of the specially-designed vests for sailors, which allow more freedom of movement than the standard model, while providing just as much buoyancy); paddles or oars, in case the wind doesn't blow; bucket and/or pump for bailing (a sponge for getting up the last drops is a good extra); waterproof packet of distress signals — orange smoke, night flares, distress flag; anchor, and line. Finally, make sure you do your practice sailing out of the main channels, away from waterskiers and fishermen. Others will appreciate your courtesy, and you'll have a better time.

Parts of the Boat

The most important element in any boat is the hull, the container that supports the crew and their gear. While most small sailboat hulls don't have the added necessity of holding up a large engine and fuel system, they do need to provide relative stability against the heeling (tipping) forces imposed by the wind on mast and sails. There are three main ways of achieving hull stability:

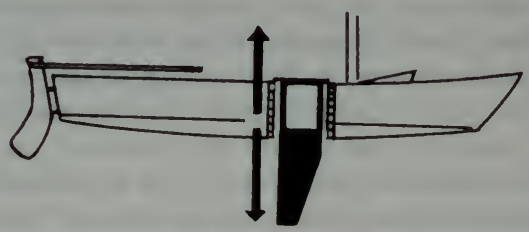
10 - 3 Vee-bottom Hull

10 - 4 Ballast Keel Hull

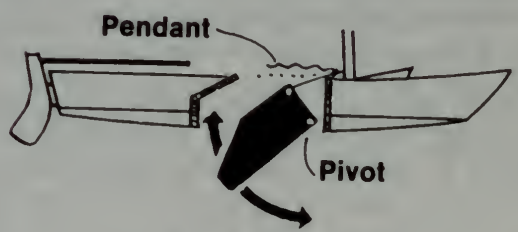
1. Hull shape: a wide, flat- or vee-bottomed hull has what's called *initial stability* — its tendency is to stay on an even keel, because of its shape. To keep it from slipping sideways (called "making leeway") a fin-shaped keel is attached to the bottom. If the keel is retractable, it's called a *centerboard* or *daggerboard.*

2. Ballast counterweight: to balance the weight aloft, and the wind pressure on the sails, the keel may have cast into it a heavy metal weight, usually lead or iron. The lower the weight, the more effective the ballast keel. Heavily ballasted boats are often rounded in cross-section, as this is an easier shape to drive through the water.

3. Live ballast: In smaller boats, the crew shifts from side to side to supplement or replace ballast and/or hull shape support. Most boats sail best when heeled only slightly, and the crew *hikes out* to a greater or lesser degree to keep the boat on her feet. When not hiking out, the crew sits in the cockpit, a recess in the deck with a raised edge (the coaming) that keeps out spray.



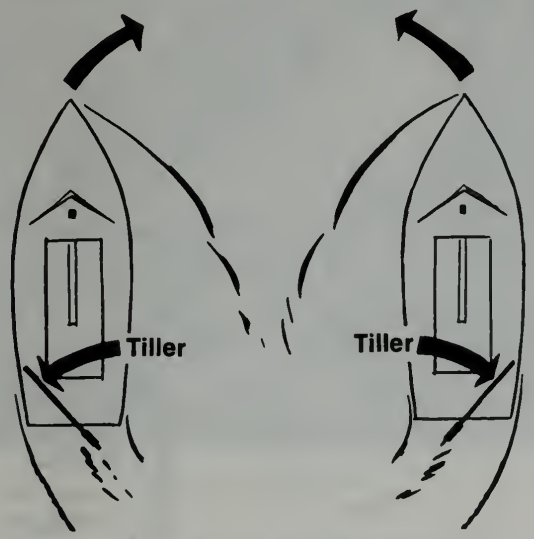
10 - 5 Daggerboard



10 - 6 Centerboard

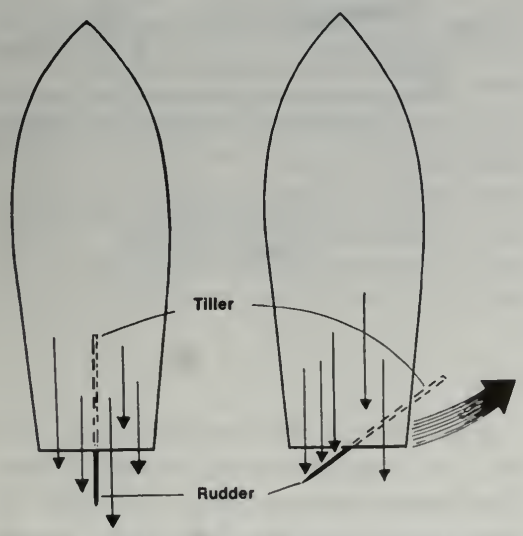
A small sailboat's cockpit isn't very roomy, and often the crew must share it with the centerboard or daggerboard *trunk* — the watertight casing in which the board rests when raised. A centerboard is pivoted, as in the illustration, at its forward end, while the simpler daggerboard is raised up and down in its slot. Obviously, a boat with either type of board can operate in much shallower water than can a boat with a fixed keel — but with the board all the way up, a boat under sail tends to slide downwind almost out of control.

Most small sailboats are steered by a simple tiller —rudder combination. The rudder is hinged to the boat's transom (in smaller craft), and the tiller is just a lever to increase the power of the helmsman's muscles. In some boats, where the helmsman hikes out, there's a tiller extender to add inches to his reach.



10 - 7 Tiller Action and Boat Heading

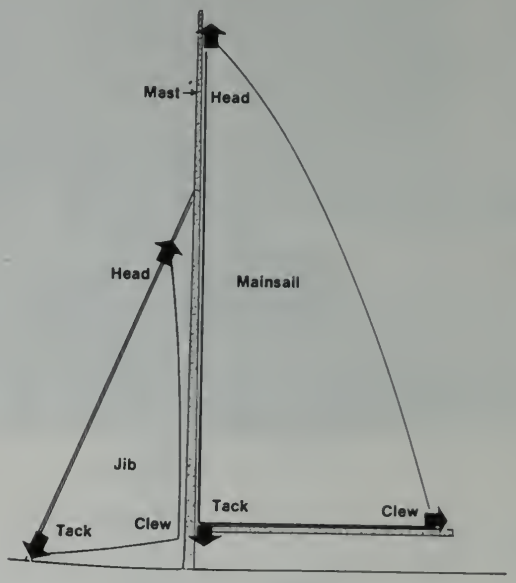
The tiller works as shown in the illustrations. All you need to remember is that pushing the tiller to the boat's *port* side makes the bow swing to *starboard,* and vice versa: Move the tiller away from the direction in which you want the boat to go. After an hour or two, it becomes second nature.



10 - 8 Rudder Drag Changes Heading

The Sails

A vessel can operate efficiently with anywhere from one to a couple of dozen sails. Most beginners' boats, however, have either one or two sails, the *mainsail* and the *jib.* Each, as you can see, is triangular in shape, and the main parts of each have the same names. Many sailors find it helpful to stencil *head* and *clew* on the appropriate corner of their sails.



10 - 9 Corners of Main and Jib

While the mainsail is normally larger than the jib, this isn't the case on all boats. The mainsail's leach is extended by strips of wood or plastic — the *battens* — while the jib is normally without battens, especially if it overlaps the mast.

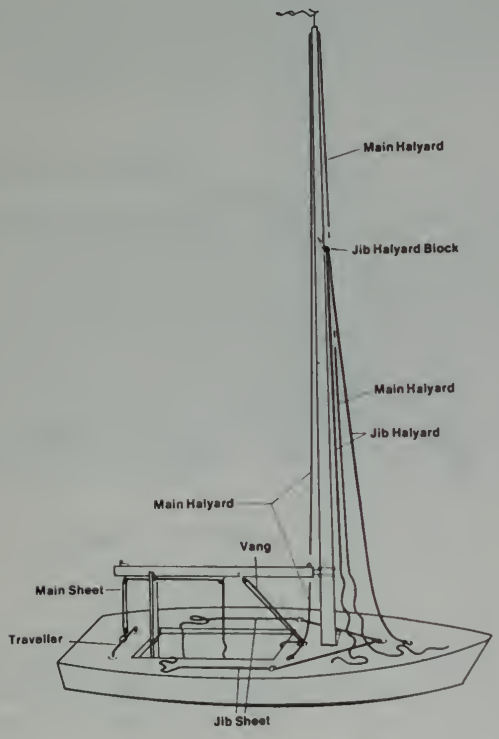
Both sails are raised by lines called *halyards* that run through pulleys and back down to cleats on deck. The mainsail, once raised, is controlled by another line called the *mainsheet,* usually made fast near the sail's clew. The jib has two sheets, one on each side of the mast, leading aft to cleats alongside the cockpit.

Most sails today are made of Dacron, an artificial fiber that is very strong and resists rot. Dacron sails require minimum maintenance, but it's a good idea to wash them at least once a year (in mild detergent and warm water) and have your sailmaker check them over for wear and tear once a season.

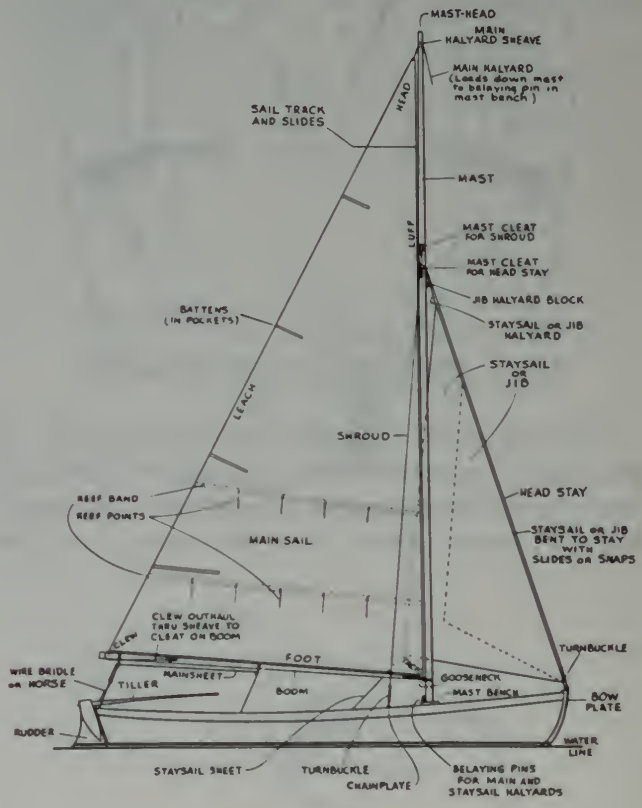
The Spars and Rigging

Obviously, cloth sails need a rigid framework to hold them up and extend them to the wind. Light wood or metal *spars* form this frame — the vertical mast and, hinged to it by a universal joint, the horizontal boom combine to extend two sides of the mainsail. While the sail itself may be fastened just at head, tack and clew, its foot and luff are usually set into grooves in the boom and mast respectively.

All these wires — the stays and shrouds — are known collectively as *standing rigging.* Their purpose is to keep the mast standing straight against the many stresses imposed upon it. In complex boats, there may be many pieces of standing rigging, and in the very simplest sailing surfboards, there is no standing rigging at all — the mast is set into a reinforced hole in the deck, and is strong enough to keep upright without stays or shrouds.



10 - 10 Sheets and Halyards



10 - 11 Nomenclature of a Sloop Rigged Daysailer

The jib is not attached to any spar, but is snapped with special fittings to the *forestay,* a taut wire running upward from the bow to keep the mast from falling or bending backward.

Other stainless steel wires support the mast in other directions — a backstay (not always found in smaller boats) counteracts the pull of the forestay. Shrouds run from the masthead to the sides of the boat, where they are made fast to chainplates, which distribute the load to the sides of the boat.

Here, then, is the complete boat, ready to sail. Most of today's popular daysailers have a fairly close resemblance to this open-cockpit *sloop* (a boat with one mast and two basic sails). Some boats are more complex in their rig, and some are markedly simpler. On the next page are a few other types of boats you may see on American waters.

10 - 12 Sailboard

Essentially a surfboard with a mast and sail, this is about as simple a boat as one can find. Its type of sail is called *lateen,* and was invented by Arab sailors in the Mediterranean. While very fast and much fun to sail, boardboats like this one require very quick reactions and frequently capsize. They can be easily righted, however, often in a matter of seconds.

10 - 13 Catboat

The native American catboat originated as a working fishing boat well over a hundred years ago. Its single sail is called a *gaff rig,* because of the extra spar — the gaff — which extends the upper edge of the sail. It is an easy boat to sail in gentle winds, but can be demanding in breezes over 10 or 15 miles per hour.

When individual sails get too big to handle, the obvious thing to do is divide them up into more sails, as on this *ketch,* a popular type of cruising boat. Other two-masted boats include the *yawl* and *schooner.*

10 - 14 Ketch

10 - 15 Catamaran

Some sailors prefer two-hulled catamarans, like this one. The rig is a variety of catboat, but the twin hulls are very narrow and easy to drive through the water, allowing high potential speeds. The crew sits in a canvas or webbing trampoline between the hulls, steering with a crossbar linked to double rudders.

Wind

Whatever the boat's shape or rig, it uses the same fuel — wind. Defined generally as *air in motion,* wind for the sailor is two different things, *true wind* and *apparent wind.*

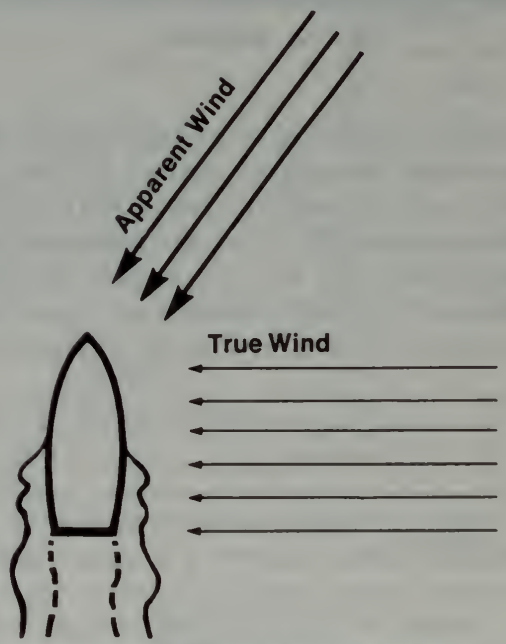
True, or geographic, wind is what you feel when standing in one fixed place ashore. True wind direction is registered ashore on flags, on weathervanes, or on sophisticated instruments.

Apparent wind, which is what a rider feels in a moving vehicle, is a combination of true wind force and direction, and the force and direction of the wind caused by the vehicle's motion. Let's break that definition down a bit more, by use of an example or two.

On a windless day, you set out from shore in a motorboat moving at 10 miles per hour. If you put your head up over the windshield, you'll feel a 10-mile-per-hour wind blowing directly in your face — but if you throttle back, the wind drops. This is a false wind, caused by the boat moving through the air — not air moving past an unmoving boat.

Later in the day, a north wind of 5 miles per hour springs up, and you head your motorboat, at 10 MPH, directly into it. Put your head over the windshield and you'll feel a wind of 15 MPH: the true wind of 5, plus false wind of 10. Now turn and run in the opposite direction: The apparent wind drops off to 5 MPH: false wind of 10, minus true wind of 5.

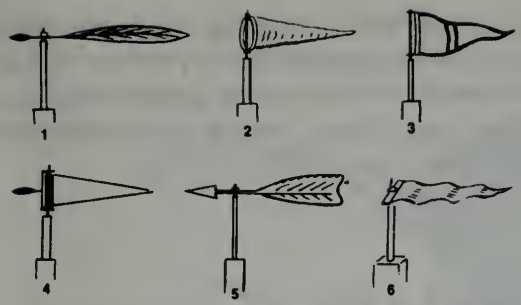
So far so good, but with sailboats it's often more complicated. If you are sailing with the true wind



10 - 16 True and Apparent Wind

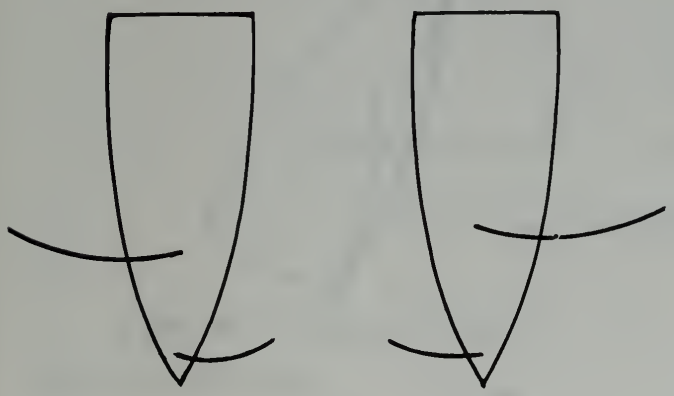
coming at right angles to your boat, and a false wind equal to your boat's speed coming over the bow, the apparent wind will be coming from somewhere between the two, stronger than either true or false wind.

There are ways of figuring out the exact strength and direction of apparent wind, but it's really not necessary. Just remember that what you feel in a moving boat is not the wind people are feeling



10 - 17 Types of Masthead Wind Vanes

ashore. To find apparent wind direction, most sailors use a masthead wind vane, like the ones shown, or a strip of light cloth about halfway up the shrouds. Be sure that your wind vane is not blanketed by the sails or by another boat.



10 - 18 Running:
Wind From Dead Astern

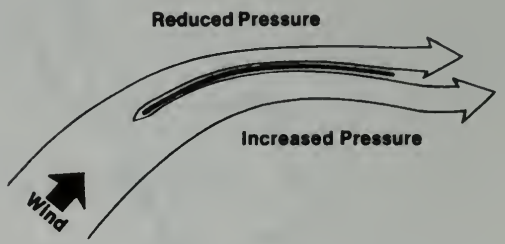
Running

It's easy to understand how a boat can sail with the wind astern, as in the diagram. With the boom fully extended to one side or the other, the sail simply obstructs the wind; the boat is pushed forward. Because of wind eddies off the mainsail, the jib often flutters helplessly when a boat is running. If the jib will stand out on the opposite side to the main (sailing *wing-and-wing,* it's called), you may be able to add a bit of speed. This kind of sailing is called *running.*

Beating

Ancient sailing vessels nearly always sailed more or less directly before the wind, yet modern sailboats can head to within 45° of the direction from which the true wind is blowing. Because of the effect of apparent wind, it often feels as if your boat is sailing almost directly into the wind.

How is this possible? Basically, what happens is that the sail which acted like a wall when the boat was running now behaves like an airplane's wing. Looked at from above, a sail's shape is not unlike a side view of an airplane wing. As many people know, an airplane is held up — lifted — not by the air underneath its wings, but by the air passing over the curved upper surface.

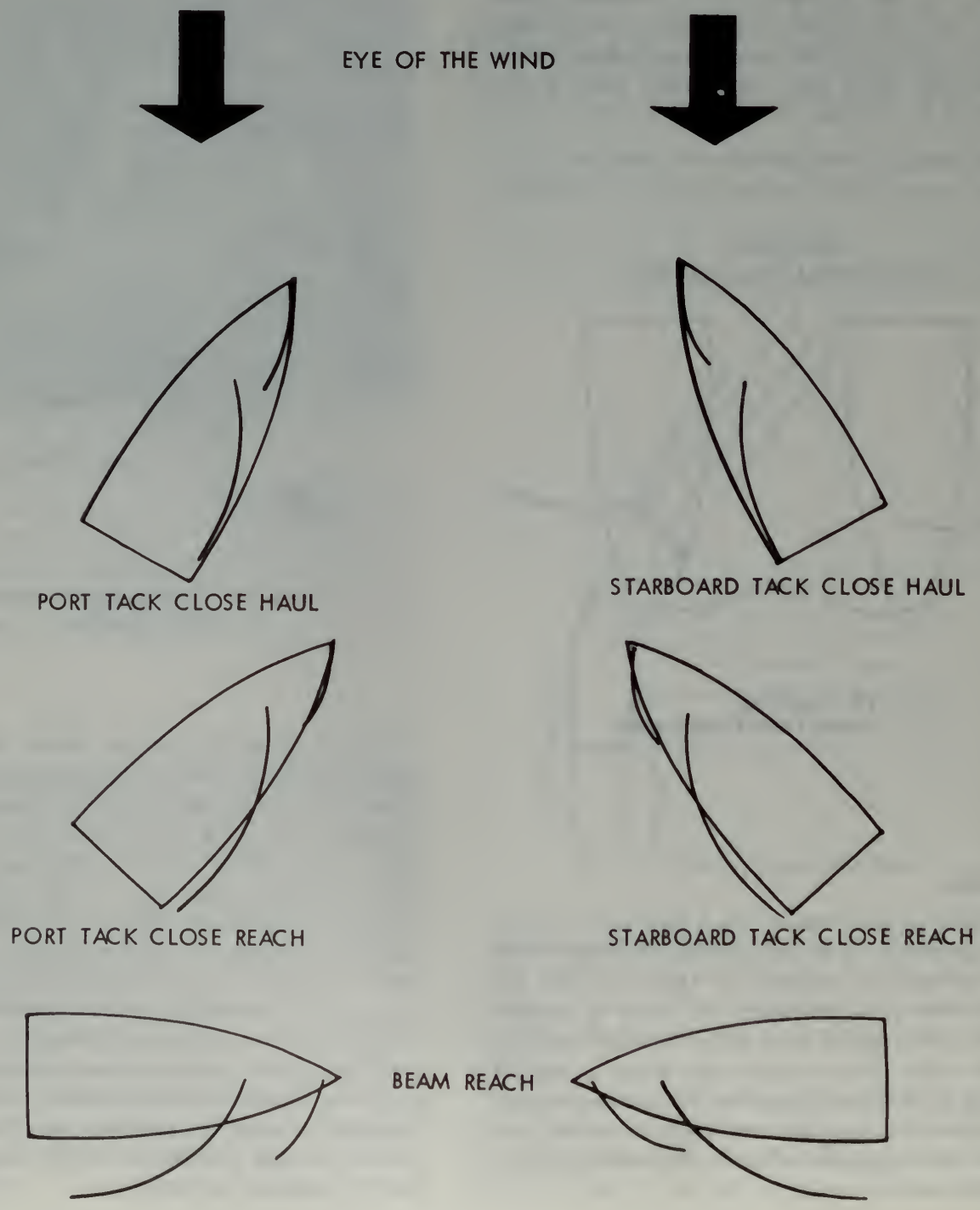


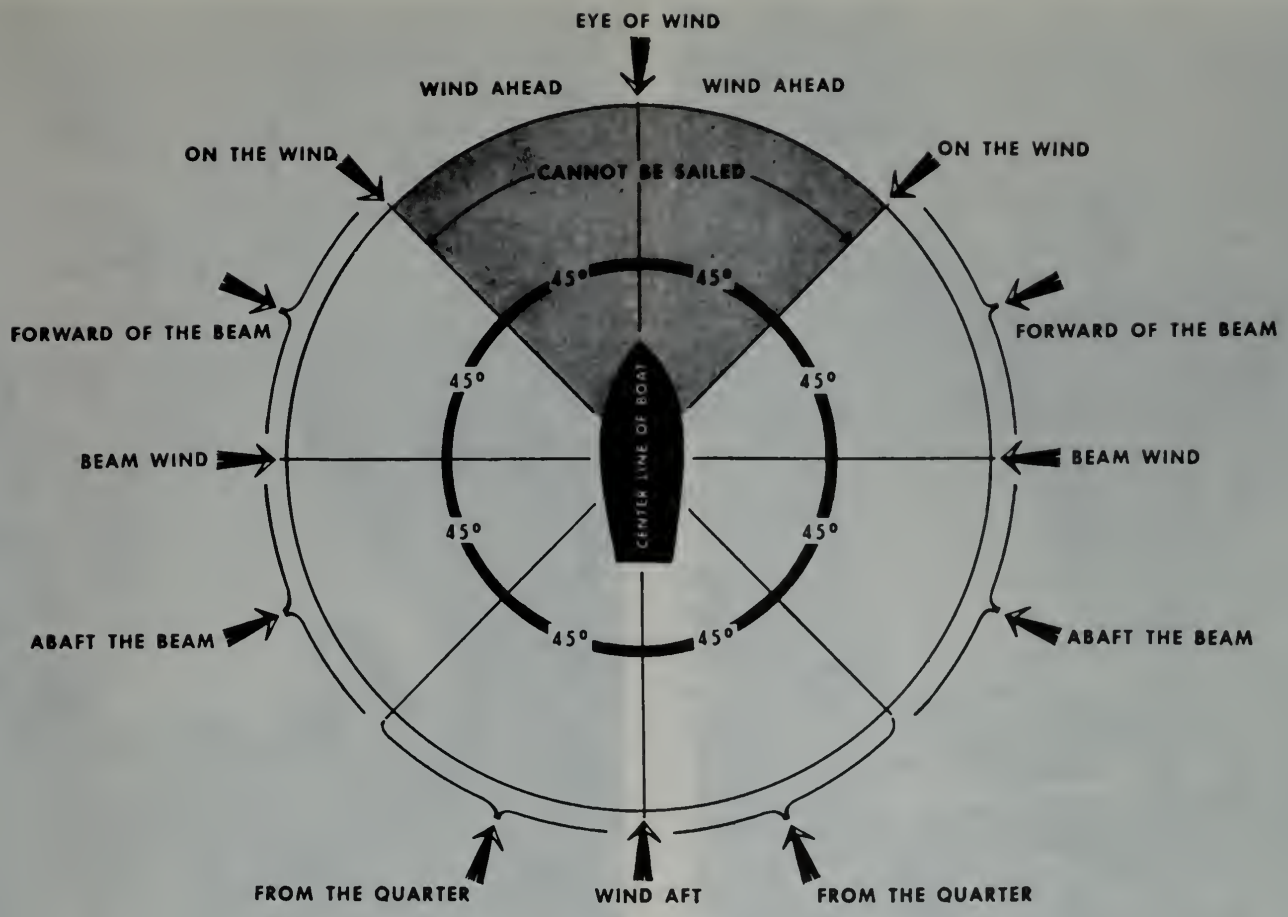
10 - 19 Air Pressure On a Sail
When Beating

The air blowing over the convex wing or sail creates a partial vacuum (for reasons too complex to go into here), and the wing or sail is lifted up and forward — carrying the plane or boat along. The lifting force operates most strongly in the forward third of the sail's area, and the lift itself is at right angles to the sail at any given point. Therefore, only part of the lifting impetus presses the boat forward, while much of the force urges the boat sideways. Because the underwater shape of a sailboat hull is designed to take maximum advantage of forward pressure, while at the same time resisting sideways pressures, the boat moves forward — into the wind. This kind of sailing is called *beating,* or sailing *close-hauled* (because the boom is hauled as close in to the boat's centerline as possible).

Anytime a boat is not beating or running, it is said to be *reaching*. There are three kinds of reaches — a close reach, when the apparent wind is coming from forward of amidships; a beam reach, when the apparent wind is at right angles to the boat; and a broad reach, when the wind is coming from aft of amidships. In most reaching, the forces operating on the sail are a combination of push and lift, and on a beam reach, the boat often gets the most possible help from each force — which is why beam reaching is often the fastest kind of sailing.

10 - 20 Sail and Boat Attitudes Relative to Wind When Close Hauled and Reaching





10 - 21 Possible Headings Relative to Wind Direction

The Points of Sailing

Here is a diagram showing all the possible headings for a modern sailboat reacting to winds from different direction. Note the shaded area, a 90° arc which cannot be sailed. This unusable portion of the available headings extends 45° on either side of the *eye of the wind* — the direction from which the wind is blowing.

These are true wind directions, of course: Close-hauled, a skipper will find his wind vane seems to indicate that he is sailing to within 10° or 15° of the wind's eye, but that's only the effect of apparent wind aboard the boat.

Winds blowing from the right side of the diagram are coming over the boat's starboard side. When the wind blows from starboard, a boat is said to be sailing on the *starboard tack*. When the wind blows over a boat's port side - whether forward of or abaft the beam - the boat is on *port tack*.

Changing Direction

Sooner or later it happens that a boat will need to change from one tack to the other. There are two ways of doing this, depending on whether the boat is sailing close hauled or is running.

Tacking, or Coming About

This is the safest and most usual way of changing direction, always used when a boat's course is toward the wind's eye. Tacking successfully is a matter of practice and timing, and the whole maneuver can be divided into five steps.

10 - 22 Tacking: "Ready About!"

1. "Ready about!" The skipper (usually the crewmember who is steering) has decided it's time to change course. "Ready about!" is his way of alerting the rest of the crew to his intentions. Normally, the crew is sitting on the windward (toward the wind) side of the boat for balance; everyone makes ready to shift sides. One crewmember unties the jib sheet and holds it, ready to release.

2. "Hard alee!" calls the skipper, pushing the tiller to leeward — away from the wind. The crew shift their weight to the middle of the boat, crouching to avoid the boom.

3. Through the wind: The bow is now passing through the wind's eye, as the boat pivots. The jib sheet is released, but the other jib sheet is not yet hauled. As the boat's bow passes through the wind, the crew complete their weight shift.

10 - 23 Tacking: "Hard Alee!"

10 - 24 Tacking: Through the Wind

10 - 25 Tacking: Boom Across

4. Boom across: The mainsail boom swings to the opposite side of the boat, as the mainsail fills with wind from the other side. Crew takes in the leeward jib sheet until the sail stops fluttering. The mainsheet, not having been released, has allowed the boom to swing just far enough over to leeward so the mainsail fills properly.

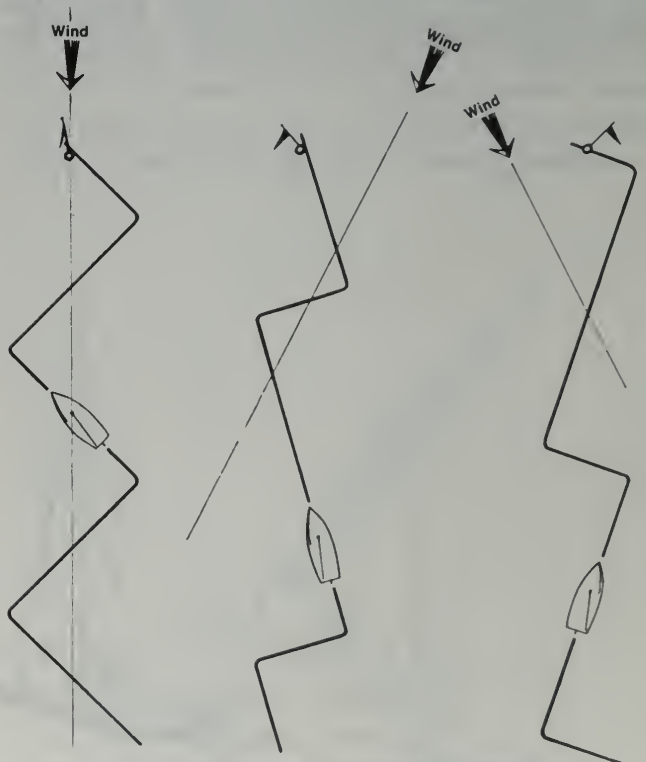
5. Settling down on the new tack, the crew coils down the jib sheet as the boat gains speed.

It may happen that a boat is moving so slowly that it will stall out at step 3. and refuse to go through the eye of the wind. If this happens, let the jib sheets run free and wait till the boat falls back on the old tack. Then build up speed by sailing on a close reach before tacking again.

10 - 26 Tacking: On the New Tack

Tacking along a course

It often happens that a sailboat must travel some distance to windward, in a direction which makes a direct heading to the destination impossible. In a situation like this, the sailboat skipper zig-zags in a series of tacks toward his mark, as shown in the illustration.



10 - 27 Tacking to a Windward Objective

If the mark is directly upwind, the tacks will be of equal distance, except perhaps for the last one or two: Since it takes time to come about, a series of a few long tacks is faster than many short ones — yet it's sometimes much easier to keep the mark in sight with shorter tacks.

When the mark isn't directly upwind, yet cannot be reached on a single heading, the course will not be composed of equal port and starboard tacks: One or the other tack, as illustrated, will be much more advantageous.

In calculating when to tack, the skipper should take into account the leeway (or sideways slippage) of his boat. All boats make leeway when sailing close hauled, and the amount of leeway depends largely on a boat's design. Generally speaking, it's a mistake to try to sail too close to the wind: This causes the boat to stall for lack of lift, and to lose speed gradually. Keep the sails full and keep the boat moving at all times, and if a wave slows you up, head away from the wind to a close reach till you regain speed.

Jibing

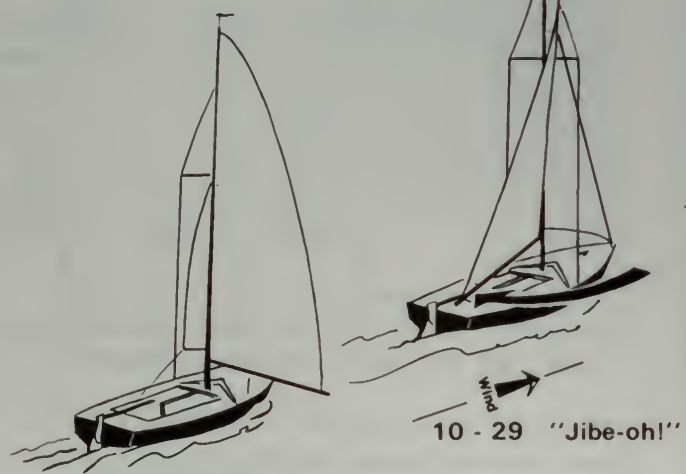
Timing is also the key to changing tacks when heading downwind, which is called jibing. Note, however, the one important difference between the two maneuvers: Whereas the attached edge of the sail passes through the wind's eye when tacking, the free edge does the swinging when you jibe: The effect can be similar to what happens when the wind gets behind an open door and slams it closed.

1. "Stand by to jibe!" calls the skipper. Uncleat the mainsheet and begin to take it in quickly, coiling it so that it will be ready to run free when needed. Don't worry about the jib. Get ready to shift crew weight.

2. "Jibe-oh!" and the skipper puts the tiller over — not too hard — toward the wind (or away from the boom: it's the same thing). Crew stands by to let the mainsheet run.

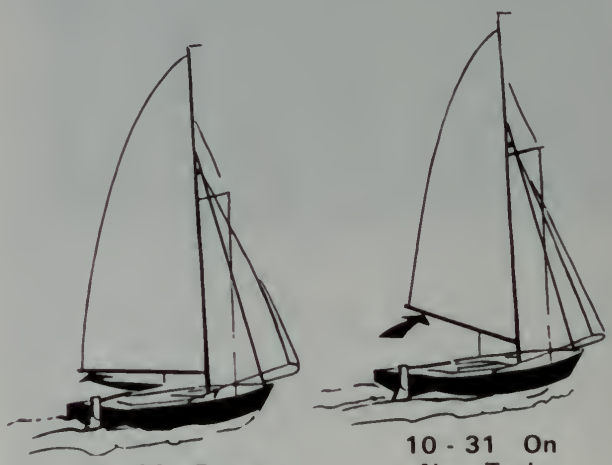
3. Boom across — but it will swing fast, picking up speed as it comes. The crewman's role is vital: Do *not* snub the mainsheet up short, so the boom fetches up with a jerk. Rather, let the sheet out in a controlled run (wearing inexpensive painter's gloves is a good idea the first few times). When the boom is out at right angles to the boat, snub its sheet.

4. Off on the new tack. Now you can try to get the jib to set wing-and-wing on the opposite side, if you want.



10 - 28 "Stand By to Jibe!"

10 - 29 "Jibe-oh!"

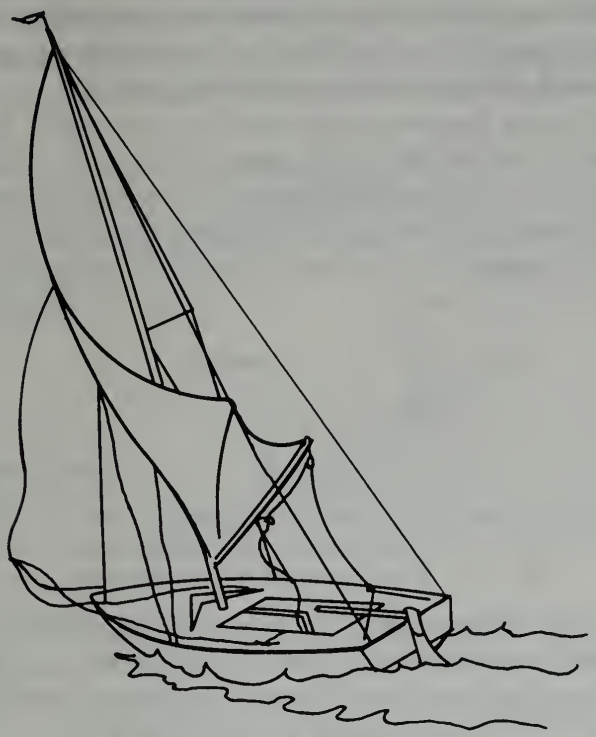


10 - 30 Boom Across

10 - 31 On New Tack

Accidental jibe

We saw earlier that a jibe is by its nature a less controlled maneuver than coming about. In high winds, or when the skipper is careless, a jibe may be quite dangerous:



10 - 32 Possible Result of an Uncontrolled Jibe

1. If the mainsheet is snubbed too abruptly, the boat may be jerked over and swamp or capsize.

2. If the sheet is not snubbed, the swinging boom may hit the leeward shroud, damaging the boom or shroud, or even dismasting the boat.

3. If the sheet is not controlled as the boom swings, the boom may arc upward and snag the backstay, breaking it or capsizing the boat.

Tacking downwind

When winds are gusty, the prudent skipper whose course lies downwind will frequently change direction by tacking instead of jibing, and will sail a series of broad reaches, instead of heading directly downwind on a course where a small wind shift may invite an accidental jibe.

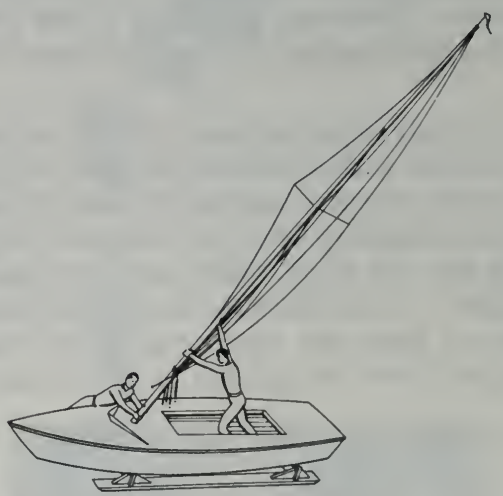
To tack downwind, the boat must first be brought round to a close reach, then swung through the wind's eye. Trying to come about from a broad reach will seldom work, as the boat will lose its turning momentum as the wind ceases to fill the extended sail.

Rigging your boat

Many small boat skippers keep their craft at a pier or mooring all season, but an increasing number rig and launch their boats each time they go sailing. Rigging a small boat is no great problem, and every sailor should know how to set up and tune his own rigging.

10 - 33 Set Mast on Supports to Check Rigging

First lay the mast on supports — a pair of carpenter's horses are ideal — and make sure the stays, shrouds, and halyards are all properly attached: Do not lose track of which is the forward side of the mast. When everything's ready, bundle the standing rigging and halyards loosely and lash them to the mast with a couple of turns of twine. Don't put these lashings on any higher than you'll be able to reach when the mast is raised, however.



10 - 34 Stepping the Mast

Now have one crewmember guide the mast into its step — facing the right way — while the other walks the mast forward: Watch where you're putting your feet. If the mast is large, it may be necessary to have one crewmember take the jib halyard to help pull the mast upright (but first be sure the other end of the halyard is made fast!).

10 - 35 Taping a Turnbuckle

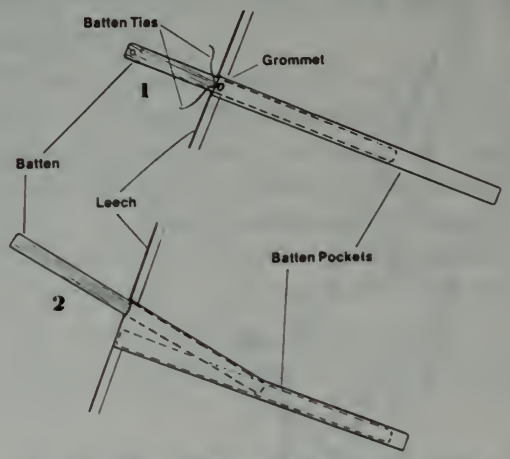
When the mast is upright and firmly stepped, attach the stays and shrouds to the proper turnbuckles or directly (in smaller boats) to the chainplates. Now wind the turnbuckles or shroud attachments with waterproof tape, to prevent the hardware ripping the sails.

Now attach the boom by its universal joint (the *gooseneck*). Insert the pintles of the rudder into the gudgeons on the transom. Lower the centerboard or daggerboard (assuming the boat's in the water). Make fast the mainsheet to its deck fitting and to the boom.

You're ready to put on the sails. Head the boat as nearly into the wind as you can. (If you're at anchor, the boat will probably head into the wind by itself.) Bend on the mainsail first: Take it from the sailbag, making sure you know which corner you have in your hand — it should be the clew. Insert this into the groove along the upper edge of the boom, feeding the foot of the sail into the groove until the clew is as far out along the boom as it will go. Now attach the tack of the sail to the tack fitting. There's a fitting at the outer end of the boom — the outhaul — designed to set up tension on the foot of the sail, and this should be pulled reasonably tight.

10 - 36 Bending the Mainsail

Your sail may have a track on boom and mast, in which case the corresponding foot and luff of the sail will be fitted with slides that ride the track. If this is the case, you can test the tension of the outhaul by tweaking the foot of the sail: It should be taut enough, when set up, to vibrate slightly.

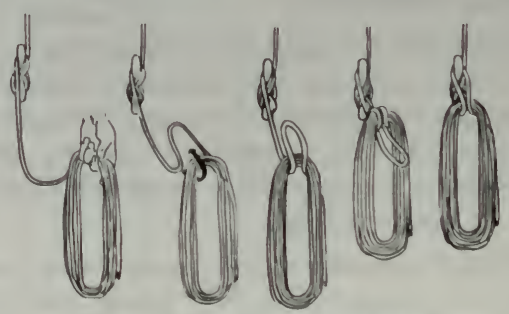


10 - 37 Two Types of Batten Pockets

Insert the battens in the batten pockets, as shown. Most mainsails have two or three different sizes of battens, with matching pockets. Make sure the thin end of the batten goes in the pocket first.

Make fast the halyard to the head of the sail. A bowline is a good knot to use. After checking to be sure the halyard isn't fouled on any of the rigging, and that the mainsheet is uncleated, so the boom can swing free, raise the sail, feeding its luff into the mast groove. The sail should be hoisted till there are parallel creases visible along the luff.

Now cleat and coil the halyard neatly. Exactly how you do it isn't that important, so long as the halyard is stowed so it cannot escape and at the same time is quickly releasable.



10 - 38 Coiling the Halyard

To raise the jib, attach its tack to the tack fitting which is usually a part of the forestay chainplate. Next, clip the snaps along the luff to the forestay. Make sure all the snaps are facing in the same direction: If they're not, you have a twist in the luff. Make fast the sheets to the clew and the halyard to the head of the jib, again using a bowline knot if special hardware snaps are not provided.

Raise the jib until the sail's luff is as taut as you can get it (but not so taut that the forestay begins to sag). Cleat and coil that halyard. As a point of interest, mainsail halyards are generally led to the starboard side of the mast, jib halyards to port. It's not a vital thing, but if you always lead the halyards the same way, you won't have to worry about which is which.

Final check

When you're learning to sail, its a good idea to make a final pre-voyage check before leaving the pier or anchorage.

1. Weather: Does the sky look as good as the forecast? If not, re-check the forecast or stay home.

2. Equipment: Is everything aboard? Accessible? Stowed so it won't fall or fly overboard?

3. Float Plan: All boatmen should leave the following information with a reliable person ashore — (1) Where you're going; (2) When you expect to return; (3) Who's aboard; (4) What the boat looks like, *in detail.* When you get back, remember to cancel out your float plan.

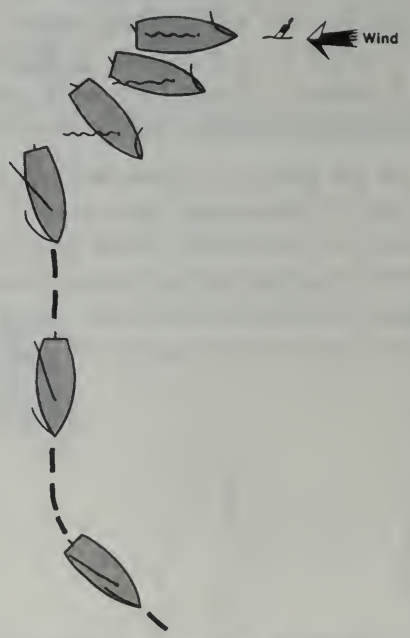
Setting Out

Leaving a pier, beach or mooring is the first test of your sailing skill. Before you cut loose from shore, plan ahead: Know what to expect, and what you're going to do next. Don't act until you have a good idea what nearby skippers, swimmers and fishermen are up to. And bear in mind that a boat has no brakes: The only way to stop a sailboat (short of running into something solid) is to head into the wind.

1. Start headed into the wind, with centerboard fully lowered. While you're still learning, it's not a bad idea to paddle to some quiet, deserted spot in the harbor and drop an anchor with a float, to serve as a practice mooring.

10 - 39 Backing the Jib

2. When all is clear around you, have your crewmember cast off the line to the mooring buoy or float. As the boat drops back, the crewmember grasps the clew of the jib and holds it out to one side of the boat or the other to catch the wind. At the same time, you put the tiller over on the opposite side the jib is extended. The boat will begin to turn in the opposite direction, as in the illustration.



10 - 40 Leaving the Mooring

3. As soon as the boat is approximately at right angles to the wind, the crewmember lets go of the jib clew and pulls the lee side jib sheet taut, while the skipper takes in the mainsheet. The sails should be taken in just enough to stop fluttering.

You're on your way.

Sail Trim

Your mast should be straight on all points of sailing — if it isn't, correct the adjustment of turnbuckles until it is. Proper sail trim does *not* require that the boat be on its ear, foaming along. Most boats, remember, sail best on their bottoms. When coming to a new heading, let out or take in the sheets until the sails stop shaking — no more. If the wind changes direction, but your heading remains the same, trim the sheets accordingly.

Anchoring

There isn't space here to go into a long treatise on proper anchoring — that's another course in itself. There are many tables showing the proper size anchor for different types and sizes of boat. Your anchor should have a sound anchor line, preferably of nylon line, at least 10 times as long as the deepest spot in your harbor.

When anchoring, follow these simple steps:

1. Drop, unsnap and stow the jib as you approach your anchorage: The idea is to clear the foredeck, and to keep the sail dry and clean. Also, sails are very slippery, and one lying on deck could easily cause someone to slip overboard.

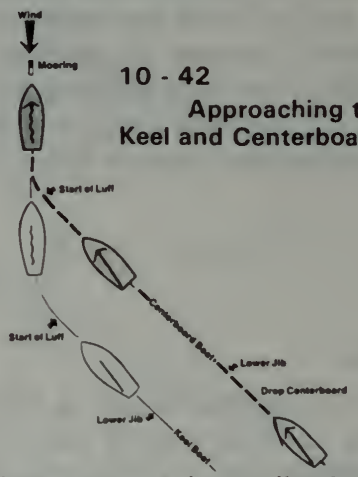
2. Head into the wind, under main alone, until the boat comes to a stop. As it begins to drift backward, lower — don't hurl — the anchor over the bow and feed the line slowly after it.

3. Once the anchor touches bottom, continue to feed out line, but keep some tension on it, to hold the boat's bow into the wind. When you've let out an amount of line equal to about seven times the depth of the water, tie off the anchor line. Check from time to time to make sure the anchor is still holding.

Landing

Whenever you come in for a landing, it seems the whole world is watching. The important thing is to avoid getting flustered: Even the best sailors have been novices in their time, and they'll understand.

1. As you approach, note how the other boats are riding. Lower your centerboard all the way. The idea is to time your turn into the wind, as shown in the illustrations, so you arrive at dock or mooring with little or no momentum.



10 - 42
Approaching the Mooring: Keel and Centerboard Boats

2. Best final approach is usually close-hauled, if the location of other boats allows. Remember to allow for leeway!

3. At one or two boat lengths downwind of the pier or buoy, head up sharply into the wind. If you've calculated right, your boat will coast to a halt, sails shaking, right at the buoy — but have a crewmember ready to grab it. If you're approaching a dock, the crew can fend off with shod feet, but make sure they're firmly seated on the deck before they try. If you miss, follow the procedures described under *setting out*, swing round and try again.

10 - 41 Anchoring and Lowering Sail

Unrigging

Most small boats' skippers remove the sails between voyages: Dacron sails deteriorate in direct sunlight, and in many harbors, airborn dirt may foul sails left furled on a boom for a few days.

Before bagging your sails, remove the battens and lay each sail out — if possible — on a clean surface, such as a lawn. Check for tears or worn spots. Now fold the sail as shown until it's a long, narrow strip, and then roll it up gently. Don't fold it or roll it hard — try to avoid creases.

10 - 43 Fold Sail . . .

10 - 44 . . . Into Narrow Strip

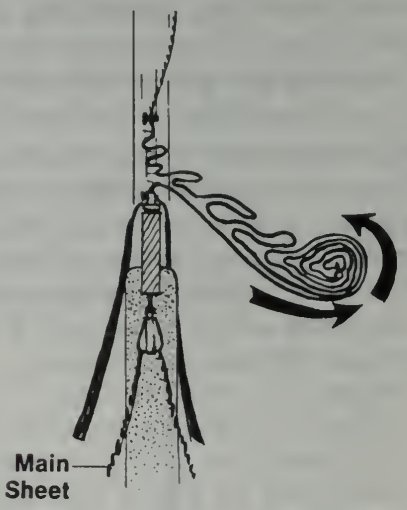
10 - 45 Now Roll and Bag Sail

If you do furl the mainsail on the boom, here's how:

1. Drop the sail and gather it on one side of the boom in one large fold of sail.

2. Roll it toward the boom, gathering the sail as you go. It's a good idea to remove the battens, if they're wood, as they are likely to take a permanent warp.

3. Lash the sail with elastic sail ties, just tight enough to hold it in place. The roll should have its open side facing down, so rain and spray will run off the sail and not be caught inside. If you have a sail cover, put it on over the furled sail.



10 - 46 Gather Sail on One Side of Boom

10 - 47 Roll Sail on Boom

10 - 48
Lash Rolled Sail

Now remove your tiller and rudder, raise the centerboard all the way, and clean out the boat. Be sure, if you sail in salt or heavily polluted water, to wipe off all varnished wood and bright metal with a clean cloth.

In heavy weather

Sooner or later, every sailor can expect to encounter weather severe enough to make sailing difficult or even dangerous. For the beginner, a careful attention to weather forecasts and to the appearance of sea and sky should postpone an encounter with heavy weather until you and your boat are enough of a team to handle it.

If you do get caught out in a sudden squall, however, chances are you'll get through it with no great trouble, if you keep your head and follow the principles of good seamanship.

Some days, especially muggy, hazy summer afternoons, breed dangerous squalls that can creep up on you before you're aware of what's happening. If you're sailing along and suddenly find the wind increasing dramatically, or see that a thunderstorm is going to strike before you can reach harbor, the first thing to do, preferably before the gusts get too strong, is drop and furl all sail. To do this, head up into the wind, let the sheets fly, and lower the sails as quickly as you can, gathering them and furling them as you do. Lash sails to boom or deck hardware, to prevent them billowing and tearing.

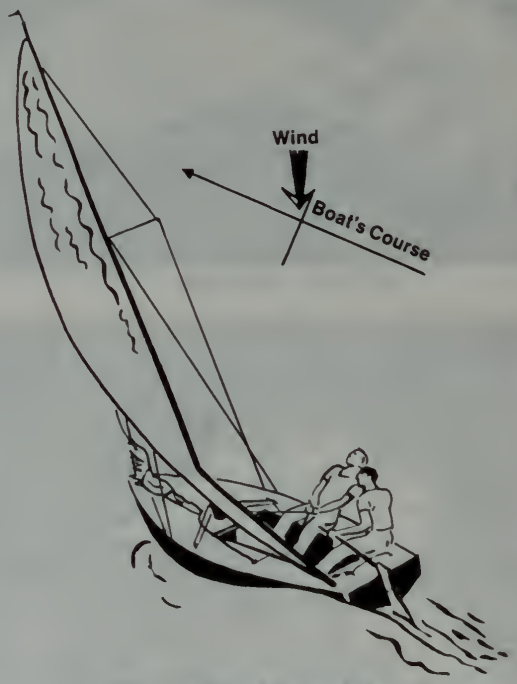
10 - 49 Drop Sails and Anchor

Once the sails are under control, put out your anchor: Even if you haven't enough line to anchor securely, the weight of line and anchor will hold your boat's bow up into the wind — the safest attitude for any boat with difficult weather.

Have your crew put on lifejackets — and set a good example yourself. It's much easier to put on any lifesaving device in the boat than in the water. Tie down all loose gear and, if significant amounts of rain or spray get in the boat, don't wait to bail.

One good thing about sudden squalls is that they're usually over fairly quickly. In 15 minutes or so, the wind should moderate enough for you to sail home under reduced sail.

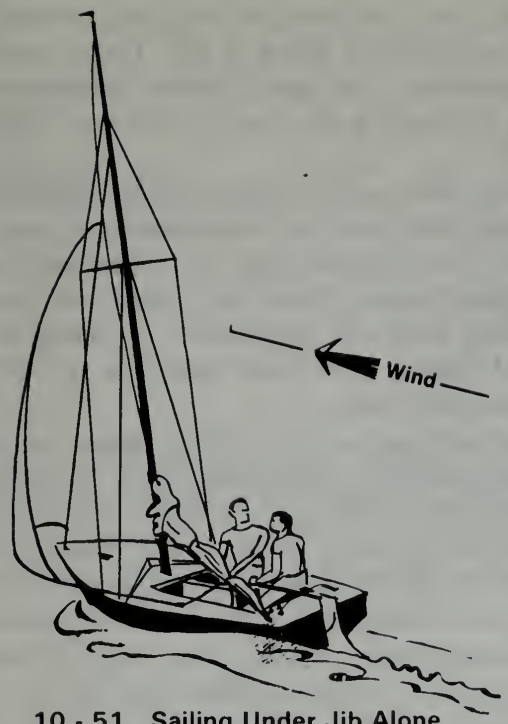
The kind of sail you set in strong winds will depend on how your boat is rigged, what sails you carry, and in what direction you want to go.



10 - 50 Sailing Under Main Alone

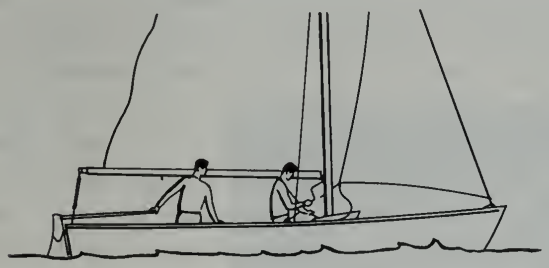
Generally speaking, most small sailboats will sail reasonably well under mainsail alone, on any heading from a broad reach up to nearly close-hauled. In a gusty wind, it's especially important to keep the boat moving, so don't try to sail as close to the wind as you normally would. Also, if you're broad reaching, be awake for sudden wind shifts: This is not the time for an unexpected jibe.

If your course is downwind, your boat may handle better under jib alone. Be sure the main is tightly furled and the boom secured. And keep the jib from unnecessary flapping, which can rip the stitching along seams.



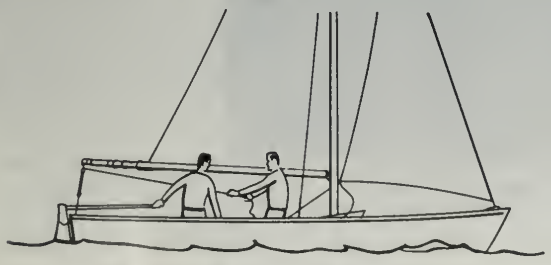
10 - 51 Sailing Under Jib Alone

Your boat may be equipped with reefing gear, in which case you can reduce the area of the mainsail, while still retaining some of it for a balanced sail plan. On most small boats today, reefing is accomplished by easing off the main halyard while



10 - 52 Rolling In a Reef

simultaneously rotating the boom with a built-in or attachable crank, to roll the sail around it like a window shade. If your boat has reefing gear, practice using it in harbor before you try it under way.



10 - 53 Reefed Mainsail

Emergency

It may happen that, despite your best efforts, the boat capsizes, or turns over on its side. With most modern daysailers, this is an irritation, but hardly a disaster. Know how to right your boat and the worst you'll suffer is a wetting.

1. Before righting, count heads to make sure crew are safe. Don life vests or jackets, if you haven't already done so. Gather floating gear and stuff it in a sail bag to prevent its escaping. Cast off halyards and pull sails down to the deck.

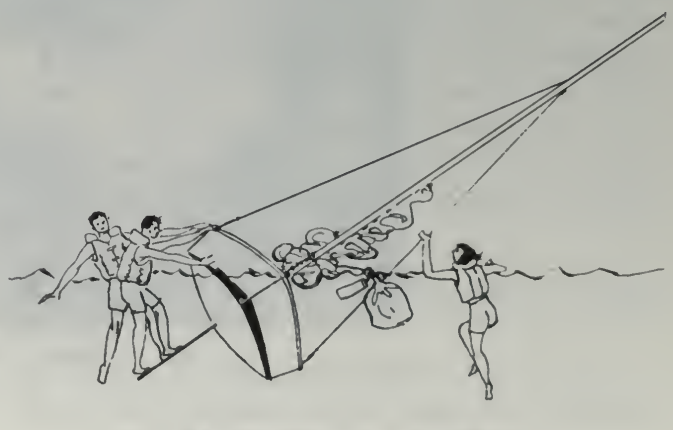
2. With centerboard extended, grasp the side of the hull, as shown, while standing on the board.

3. Chances are the boat will come upright by herself. Full of water, she will be very unstable. Swim alongside and bail until the water is six inches or so lower than the boat's sides.

4. Now a light-weight crewmember can climb in over the stern and finish bailing, after which sails can be raised again. With practice, especially in easily capsized board boats, you'll learn how to right the boat without lowering sail.

Distress

Sometimes a mast or boom is damaged to the point where the boat cannot easily be sailed. If this happens to you, or if your sail develops a sudden tear, it may be best to call for help, rather than pushing onward to incur a big repair bill. Distress signals can be carried on the smallest boat: They should be stowed in a watertight box or bag, out of the reach of small children, in a place where a capsize won't cause them to fall from the boat. Here are common ways to ask for help — never be ashamed to do so if you feel the situation is getting out of control.



10 - 54 Righting Capsized Boat

1. Flare or smoke signal: Hand-held orange smoke signals can be seen a long way. Be sure to follow instructions on the device, and hold the burning signal away from yourself and the boat.

2. A distress flag — usually a bright International Orange square of plastic — can be hoisted in the rigging.

3. A horn or whistle, repeatedly sounded in patterns of five blasts, is a recognized distress signal.

4. Waving the American flag upside-down is known to be a signal of distress.

5. With no signals at all, simply raising your arms over your head and lowering them level with your shoulders, over and over, is a standard distress signal.

When making any distress signal, be sure you do it vigorously: You may know you're in need of help, but the other fellow may think you're just waving or tooting to be friendly.

Conclusion

There's nothing difficult or mysterious about sailing, once you have the hang of it, but don't think that you'll ever know it all. That's one of the fascinations of the sport: There's always something new to learn, some way to improve your sailing skills.

Now that you've completed this introduction to sailing, there are two complementary things to do next. First, practice what you've learned: Use it till you can come about, jibe, enter and leave tight corners with real confidence. As noted earlier, a good way to learn more quickly is to crew for an experienced sailor.

Second, take another sailing course. One you may want to consider is the Coast Guard Auxiliary's own Principles of Sailing, a seven-lesson course that explains in depth what you've learned here in outline, and which will teach you more about fine points of sailing than we've had room to touch on in this short space. Cost of the Auxiliary's course is very slight - often no more than the price of the textbook - and it will expose you to the kind of information you must acquire to be a complete skipper.

10 - 55 A Modern High Performance Sloop

CHAPTER 11

Weather

Weather is one of the greatest influences on the sport of boating. It determines when you shall go, what your course will be, the time required to arrive at your ultimate destination and in many cases, the degree of your enjoyment in the passage.

As a boatman, you must realize the speed with which weather can change. You must learn to recognize those weather signs that warn of impending bad weather. You must know where to obtain the latest weather information and be able to relate this information to your own situation and capabilities.

The importance of weather to boatmen was tragically emphasized in an incident that took place in September 1967 on Lake Michigan. Seven people were drowned and many others injured by seas that were apparently too high for the boats used. The tragic part is that forecasters had given warnings of the bad weather and these forecasts were available to the boatmen, in sufficient time for the ensuing tragedies to have been avoided.

Weather forecasts the morning of the incident had warned of winds increasing to 20 to 30 knots in the afternoon and Small Craft Warnings were posted. By late morning the forecasts included a warning of thundershowers. Many boatmen either did not obtain the weather reports or did not heed their warnings.

The following report is quoted from the Coast Guard Board of Investigation convened to examine the disaster.

"On 23 September 1967 approximately five hundred motorboats, mainly outboards of 16 feet or less, were underway in eastern Lake Michigan between Empire and Manistee, Michigan engaged in salmon fishing. A large number of these craft had been launched from ramps at these and intermediate communities. A number of boats also launched directly into Lake Michigan from the nearby beaches. Many of the boats proceeded to Platte Bay, the area of reportedly good fishing. The weather began to deteriorate at about 8:00 AM. Progressively from late morning through the afternoon boatmen in the Platte Bay area discontinued fishing and beached their craft in the immediate vicinity or attempted to return in departing sheltered Platte Bay, exposed themselves to the more severe sea conditions along the coastline. About 200 boats attempting this open lake passage found it difficult and headed for the nearest beach area, and attempted to land through a heavy surf. Seven persons lost their lives, and all were occupants of boats which had capsized in or near the surf. At least 16 boats were damaged in making beach landings and a number of other boats swamped and/or capsized and were damaged but removed from the beaches before count could be made. Most occupants of the boats involved did not wear lifesaving devices although they were available to them. Fifteen persons were taken to hospitals suffering from exposure and water inhalation. None of those hospitalized were incapacitated for more than 72 hours. At least 150 persons and 75 boats were assisted from conditions of peril or distress by rescue forces."

The Board considered all available facts and concluded, in part,

"1. That the evidence indicates the damage to boats, swampings and/or capsizings, and endanger-

ing of or loss of life, which occurred in the Frankfort to Empire, Michigan area on the eastern shore of Lake Michigan on 23 September 1967, were primarily caused by the operation of boats of limited capability for the existing weather conditions by persons not experienced in open lake operations while:

a. attempting hazardous open water passages in trying to return to their launch sites,
b. proceeding within, or too close to, heavy surf,
c. attempting beach landings through heavy surf.

2. That recognizing the limited experience and boating knowledge of many boat operators, and the sea conditions prevailing during most of 23 September 1967, the general type of boat in use—less than 16 feet in length and of open construction—did not afford the desired level of safety. It is emphasized that this assessment does not reflect on the adequacy and safety of any particular size or design boat per se, but rather is made in relation to the general operator capability and operating conditions existent.

3. That the evidence indicates that a contributing cause to the casualties and endangerment to life and property which occurred on 23 September 1967 was a general lack of knowledge of boating safety by an appreciable number of boatmen in one or more of the following respects:

a. failure to obtain weather forecasts,
b. failure to recognize or heed the small craft warning signal displayed at the Frankfort Coast Guard Station,
c. disregard of the recommendations of Coast Guard and other law enforcement personnel to not proceed into Lake Michigan because of unfavorable weather conditions,
d. proceeding into the open lake at the same time other boatmen, experienced in open lake operation, aborted their cruises because of observed sea conditions,
e. failure to recognize or heed indications of deteriorating weather,
f. failure to attempt to land at the nearest available shore upon first observing the increasing winds and seas,
g. failure to wear available life saving devices while operating in heavy sea or surf.

4. That the evidence indicates that the weather conditions predicted by the National Weather Service for 23 September 1967 materialized as forecast. The wind and seas conditions progressively worsened from about 8:00 A.M. to 3:00 P.M.; it was not a sudden storm which endangered the boats and their occupants.

5. That because of the apparent general lack of knowledge of weather on the part of many operators of small boats it is probable that many boatmen do not realize that:

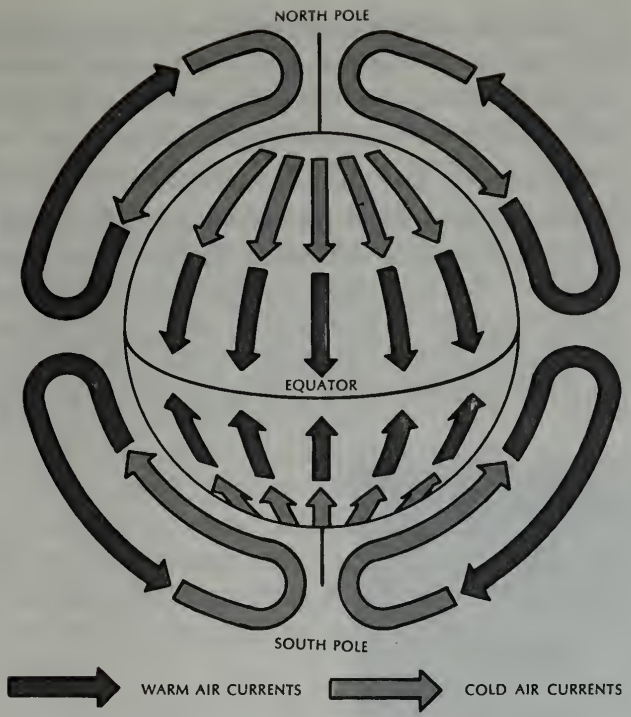
a. the weather forecast can change within a few hours,
b. the absence of any language in a forecast expressly stating a small craft warning does not remove that possibility for succeeding periods,
c. the wind force and direction must be evaluated in relation to the particular shore,
d. small craft warnings are simply precautionary and indicate that further information is available and should be obtained."

Although other factors were involved the fundamental one was the failure of the boatmen to obtain and heed weather information. Coast Guard and Sheriff patrol boats had warned boatmen to remain in harbors because of the weather but many ignored the warning.

The important lesson to be learned from this incident is that weather should be taken seriously. Get the latest report before you depart, and keep informed while you are out.

Movement of Air Over the Earth

For us to understand why weather varies from day to day it is necessary to learn something about our Earth's atmosphere. The lower atmosphere consists of air, which is a mixture of oxygen, nitrogen, and other gases, plus water vapor. You are familiar with the temperature of air on the surface; however, the temperature drops as we climb to higher altitudes and is about—50° F at 50,000 ft. Air in the lower atmosphere is heated by



11-1 Ideal Atmospheric Circulation for a Uniform Nonrotating Earth

incoming solar radiation and heat radiation from the Earth's surface. The temperature is dependent on the season and latitude.

The sun's rays are transmitted more directly and intensely to the lower latitudes near the equator, causing the air there to be heated more than in the higher latitudes. The rotation of the earth around the sun and topographical features also help to make the true circulation very complicated.

This warm air rises and is replaced by cooler air from regions closer to the poles. With this in mind, you can envision a circulation pattern such as depicted here.

Air does indeed circulate about the earth, but it is not as simple as this. The earth rotates on its axis. Just as you would have trouble making a straight line across a moving record turntable so air set in motion does not follow a straight line across the moving surface of the Earth. As the Earth rotates under the moving air, its path relative to the Earth bends to the right in the Northern Hemisphere. This is called the coriolis effect.

Upper air flowing north in the Northern Hemisphere will bend at an increasing rate until it "bunches" up near 30° N latitude. This causes an increase in atmospheric pressure and East-West winds. Since the pressure and wind are different,

11-2 Thunderhead

the weather is different here than in other areas to the north or south. So you can see the illustrated circulation pattern is oversimplified. The important fact, however, is that air masses do move about the earth. As we will see, different types of weather are associated with air masses and these also move about the Earth.

Clouds

We have stated that the atmosphere contains water vapor. Hotter air is capable of holding more vapor than colder air. When a weatherman says the *relative humidity* is now 70%, he means that at the current temperature, the air is holding 70% of the vapor it is capable of holding.

We know that air, if warmed, will rise. We also know that the temperature gradually drops as altitude increases. One cause of this is the drop in pressure. Rising humid air will also cool and will continue until it is cooled to the point where it can no longer hold its moisture and reaches 100% relative humidity. Here the moisture will condense

11-3 Altocumulus Clouds

11-4 Rain Clouds

into very small droplets and clouds will form. If enough moisture is formed into a cloud, the droplets will combine and become larger until they are too heavy to remain in the cloud. Precipitation will then occur, usually in the form of rain or snow.

There are many different types of clouds. Meteorologists can identify over 70 of them but we will not attempt to describe them.

Weathermen classify clouds according to how they were formed and their location (altitude). We saw that warmed air will rise and, if humid enough, will form clouds. Often clouds can form if air is cooled by some other means. Clouds can be located at many altitudes such as low rain clouds, high "mares tails", or thick thunder clouds extending from low to high altitudes. Often on a warm sunny day puffs of cumulus clouds will float by you.

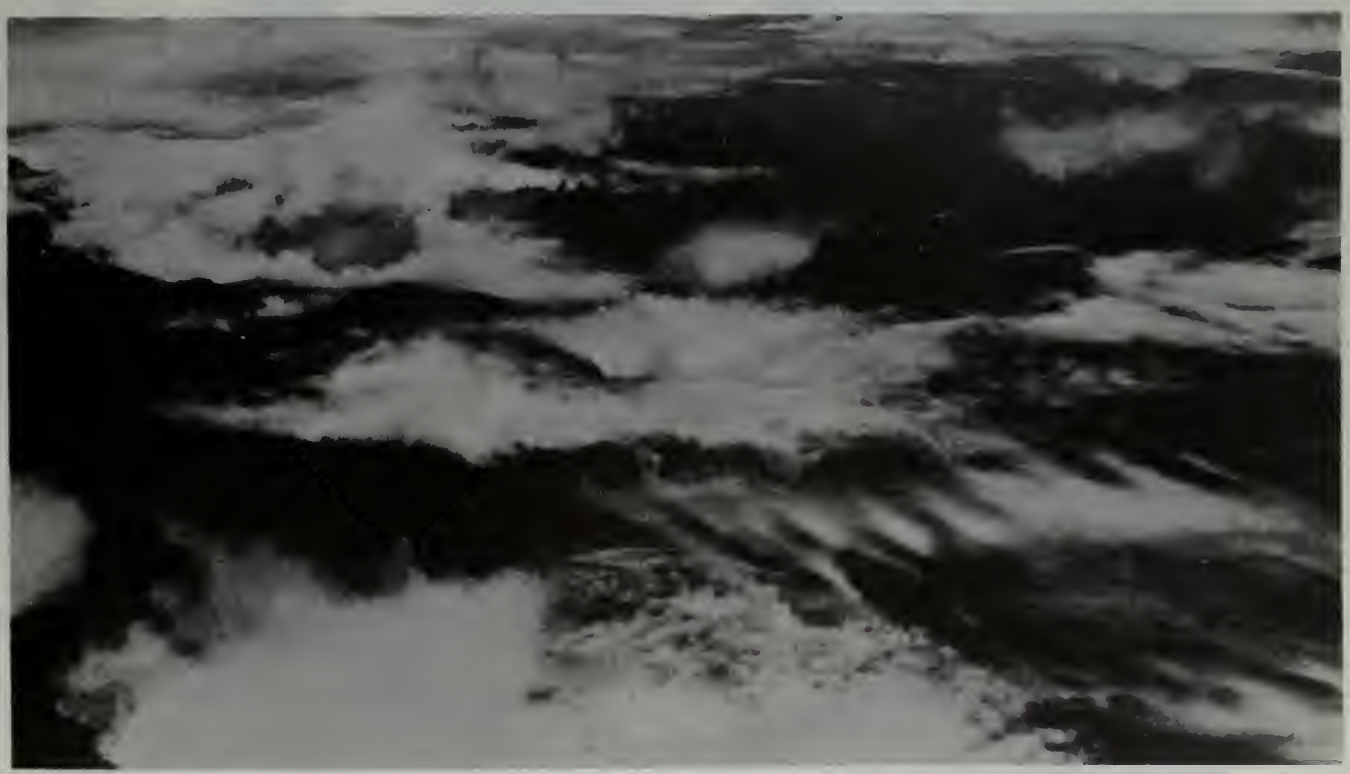
Atmospheric Stability

If the surface temperature is much higher than temperatures aloft, an unstable pattern of rising air and cloud formation will occur. If the surface temperature is equal or nearly so, to that aloft, a stable situation exists and cloud formations will be minimal. The line of demarcation between stable and unstable conditions is dependent on the relationship between both temperature changes and changes in altitude. As we will see later, an unstable condition can cause various kinds of bad weather.

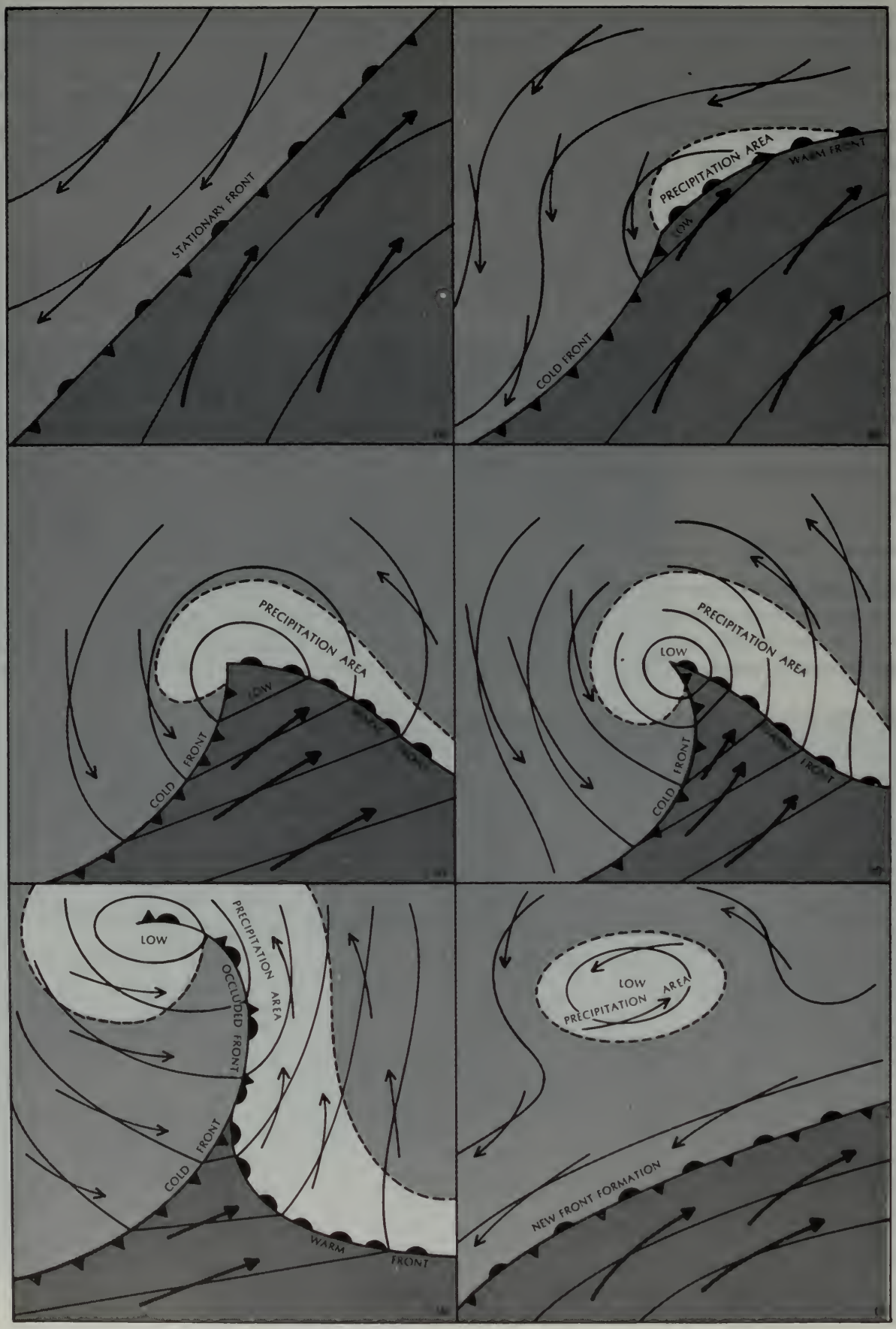
Weather Instruments

There are several devices used to describe the weather by measuring physical properties of the atmosphere. Unless you are planning to formulate your own forecast, having a lot of weather instruments will not be of much benefit to you. There are so few that would be of great use to you. Leave the reading and interpreting to the professionals.

The following definitions are intended for your general information only. An *Anemometer*, measures wind speed. A *Barometer* measures atmospheric pressure in either inches of mercury or millibars. A *Thermometer* measures degree of temperature. A *Hygrometer* measures relative humidity. A *Psychrometer* measures wet and dry bulb air



11-5 Altocumulus of a Chaotic Sky



11-6 Formation of a Low Pressure System Along a Front

temperatures. With either of these, one can use psychrometric charts to determine relative humidity and dewpoint.

Further explanation here might be helpful. Relative humidity is the ratio of water vapor in the air to the amount the air could hold at that temperature. The dewpoint is the temperature below which moisture will condense out of the air to form droplets as fog or cloud. A psychrometer is a set of two thermometers with the bulb of one enclosed in a wet gauze. The "wet bulb" thermometer will read lower because of the cooling effect of evaporation. The amount of evaporation depends on the relative humidity of the air. If the air is humid, there will be little evaporation and the "wet bulb" thermometer will not read very much lower than the "dry bulb" thermometer. In other words, the difference between the two thermometer readings varies with the relative humidity.

Air Masses

An area such as the continental United States "imports" much of its weather or at least the ingredients for it. Basically, air masses come from either the cooler regions of the North or the warmer regions of the South. If an air mass comes from the sea it will be more moist than a mass originating over land. Meteorologists note the different types of air masses and track them carefully because the movement of air masses causes weather.

Fronts

Where air masses of different types meet, fronts exist. Fronts are significant because it is along these borders that most severe weather occurs.

An example might clarify this somewhat. A mass of cold air from Canada has invaded the United States. On its border there exists a cold front. The cold air is heavy and stays low to the ground. There is warm air, probably humid, ahead of the front. Somewhere along the edge of cold air, a weak spot in the front might develop. It could be caused by a mountain in its path. Here the warm air will be surrounded by cooler air. It will rise, clouds will form, and precipitation will probably follow.

The rising pattern of the warm air will cause a drop in barometric pressure and a clearly defined low pressure area or a "low" can soon be located. Around the low, there is a wide area of clouds and precipitation.

As more warm air is undercut by the cool air, more clouds form and the area of precipitation increases. Winds tend to head into the low; but the coriolis effect veers them to the right (Northern Hemisphere) so that a circular counter clockwise pattern develops. The warm air will be surrounded on the three sides by the cool air as it circulates around the low.

Ultimately the low will be completely surrounded by cold air. The supply of warm air able to rise and form clouds is reduced to nothing. With the rising air pattern which originally caused the low pressure area now stopped, the low will become less vigorous and will eventually dissipate.

The entire process from formation to dissipation may take 3 to 10 days or more.

Different air mass types will form various kinds of weather. Weathermen compare the type of air invading an area with the air already there. If there are great differences in temperature and moisture content, a great deal of activity along the front can be expected.

Weather Forecasting

The National Weather Service formulates forecasts for the U.S. and adjoining waters. The process demands the input of a great deal of surface and upper air data from stations around the world.

Each weather station observes the following:

1. temperature
2. wind speed and direction
3. cloud type and amount of coverage
4. barometric pressure and change in last three hours
5. weather in last 6 hours and present weather
6. visibility
7. dewpoint
8. precipitation amount

The observation data from many stations are collected at a center and plotted on a weather map. Using this information, an analyst then tries to locate different air masses and the fronts that separate them. He does this by comparing temperature, barometric pressure, dew point, and wind velocity. This allows the analyst to "see" masses of cold dry air or warm moist air. By examining the various stations' reports, he can tell which way the air masses are moving and what kind of fronts he is observing, he can then locate the well defined high, or low pressure areas. Next he draws in isobars (lines that identify places of equal barometric pressure).

With all this information on the map, the forecaster can then attempt to estimate what conditions will prevail in the future. Using wind speeds and direction he can predict in what direction the high and low pressure areas will travel in a given time and what can be expected of their associated weather.

Fog

One weather feature that is of particular concern to boatmen is fog. Fog is formed when air is cooled to the point (the dewpoint) where its moisture condenses into very small droplets. This is similar to the way a cloud forms. Fog is really a cloud that is on, or near the ground.

To understand more about fog, let's review some facts we discussed earlier. Cool air cannot hold as much moisture as warm. Thus if air that is already moist is made cooler, fog will form. This occurs in several ways.

On land, if the air is very humid at sunset, the land, and the air close to it, will cool off and fog may form. This is known as *radiation* fog.

When the sun rises the following morning, it will warm the air a few degrees. The condensed moisture will disappear and the fog will dissipate ("burn off").

The fog most common to boatmen is caused by moist air moving over a cool surface. An example of this is warm moist air from land blowing over cold coastal waters. This is called *advection* fog because the temperature change is brought on by air moving to a cooler location. It is a particular hazard to boatmen because it commonly occurs on coastal waters especially in cold seasons, and it moves in a "bank" that can overtake and surprise the unwary boatman. The fog will usually be concentrated close to the water's surface and may be absent at a height of 50 feet. This is because the water is the cooling agent.

Fog is likely wherever an area of cold water exists; as for example, on the Pacific coast, where upwelling brings cold water to the surface. For this same reason, fog can form on rivers where cold water flows through areas with very moist air. The cold river will cool air near the surface causing fog. Sometimes this situation occurs below dams because water becomes cold in the deep pool behind.

Fortunately, weathermen, by carefully predicting temperature change and measuring dew point (the temperature at which moisture condenses), can predict fog with high reliability. Marine weather forecasts include information about any anticipated fog. Inasmuch as the normal weather forecasts often don't give this information, wise boatmen always get the marine forecast before departing.

Weather Information

The best source for weather information is the one that is easiest for you to obtain and most up to date. Several sources are noted here.

Your instructor will have information on the availability of each one in your area. RECORDED TELEPHONE MARINE WEATHER REPORTS are available in many large cities. If there is one in your area, it is a very convenient means of finding the forecast. Call while you are planning your boat trip, for instance, the day before, and again just before you leave to get the latest report.

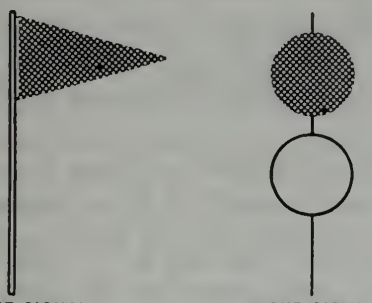
VHF-FM CONTINUOUS MARINE WEATHER BROADCASTS are another excellent source. These National Weather Service radio weather transmissions repeat taped messages about every five minutes. Tapes are updated every 3-6 hours and include weather and radar summaries, wind observations, visibility, sea and detailed lake conditions including reports from Coast Guard

units, and detailed local and area forecasts. When severe weather warnings are in order, routine transmissions are interrupted and the broadcast is devoted to emergency warnings. A sample detailed local marine weather forecast that might be included in a National Weather Service Broadcast is given below:

> "The marine forecast for the Chesapeake Bay north of Point Lookout and for the lower Potomac. Easterly winds 10 to 15 knots this afternoon, tonight, and Tuesday. Weather cloudy with rain this afternoon and tonight and chance of some rain or drizzle Tuesday. Visibility 3 to 5 miles, but variable to 1 mile or less in fog tonight."

National Weather Service radio weather transmissions can usually be received up to 40 miles from the antenna site, depending on terrain and type of receiver. The frequencies used, 162.55 MHz and 162.40 MHz lie just above the marine band; therefore, special tuners or receivers are required. An increasing variety of these are becoming avail-

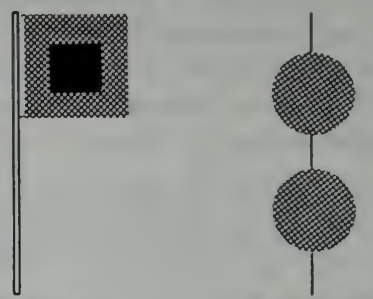
SMALL CRAFT



DAYTIME SIGNAL NIGHT SIGNAL

One RED pennant displayed by day and a RED light over a WHITE light at night to indicate winds as high as 33 knots (38 m.p.h.) and/or sea conditions considered dangerous to small craft operations are forecast for the area.

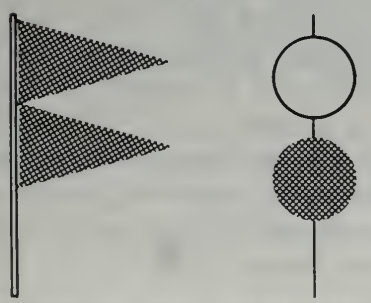
STORM



DAYTIME SIGNAL NIGHT SIGNAL

A single square RED flag with a BLACK center displayed during daytime and two RED lights at night to indicate that winds 48 knots (55 m.p.h.) and above are forecast for the area. If the winds are associated with a tropical cyclone (hurricane), the "Storm Warning" display indicates winds 48 to 63 knots (55 to 73 m.p.h.) are forecast.

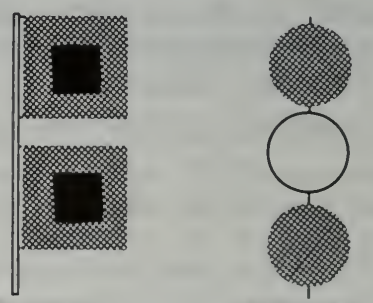
GALE



DAYTIME SIGNAL NIGHT SIGNAL

Two RED pennants displayed by day and a WHITE light above a RED light at night to indicate winds within the range 34 to 47 knots (39 to 54 m.p.h.) are forecast for the area.

HURRICANE



DAYTIME SIGNAL NIGHT SIGNAL

Displayed only in connection with a tropical cyclone (hurricane). Two square RED flags with BLACK centers displayed by day and a WHITE light between two RED lights at night to indicate that winds 64 knots (74 m.p.h.) and above are forecast for the area.

11-7 Warning Display Signals

able ranging in price from $20.00 to $200.00 or more. It's a good idea to equip your boat with one.

SCHEDULED WEATHER SERVICE MARINE BROADCASTS ON COMMERCIAL AM STATIONS are also available in a great many areas. Typical Schedule times are early morning, noon, early evening, and midnight. Some of these broadcasts come directly from the Weather Service offices and contain all the necessary information. Details for your area will be covered by your instructor.

MARINE RADIOTELEPHONE WEATHER SERVICE FORECASTS are broadcast on Coast Guard working frequencies in the 2 MHz band on a scheduled basis. An announcement is often made on 2182 kHz prior to the broadcast. The most common schedule is every 12 hours.

Since the range of 2 MHz stations is usually wide, the weather information broadcast covers a large area. You must pay special attention to information for your area. Even though the forecast for a large region is for generally good weather, hazardous weather may be experienced in a local area.

Your radio telephone is also valuable when special storm warnings are issued by the Weather Service. Special broadcasts are made over the usual marine radiotelephone stations. These broadcasts are also announced in most cases over 2182 kHz. If you have your set tuned to this frequency, which should normally be the case when underway, you will hear the announcement and instructions to tune to the correct frequency.

TELEVISION WEATHER REPORTS are presented by almost all TV stations on a scheduled basis. Some reports include boating forecasts.

NEWSPAPERS in most cities contain weather forecasts and usually a simple weather map. Beware of old information. Hunt through the forecast and you will see that it is usually more than 12 hours old. More information can be obtained from radio (AM, FM, or VHF-FM) and TV. It is suggested that these sources be consulted.

WARNING DISPLAY SIGNALS are posted in many boating areas when directed by the Weather Service. Most display sites use only the daytime warning signal and do not post nighttime signals.

Pennants and Lights

The most common signal seen by boatmen is the small craft advisory. The term "small craft" includes boats of many designs and sizes, and the advisory covers a wide range of wind speed and sea condition. It forecasts possible hazardous conditions to small boats, such as 30 knot winds or scattered afternoon thundershowers. You may see it displayed on what appears to be a beautiful day for boating and be tempted to ignore it. Do not do this. Instead, regard the small craft advisory as an alert that wind and/or sea conditions potentially dangerous to "small craft" exist or are forecast.

The more severe gale and storm warnings should be given more respect. If these warnings are displayed it is unlikely that you would want to go out.

You may note from Fig. 11-7 that the Storm Warning can have two meanings. If no hurricane is around, it means winds over 48 knots and often of much greater velocity, are forecast. When the winds are part of a hurricane system the meaning changes to 48-63 knots and a special Hurricane Warning is used for winds 64 knots and above.

Watch the Weather

We hope that before you depart on a boating trip, you take time to get the latest weather information. However, your need for weather information does not stop there. While you are out, have a radio of some kind aboard and check the weather broadcasts periodically. If you hear static on your AM radio, it may be an indication of thunderstorm activity nearby. Keep your weather eye "peeled" for the approach of dark, threatening clouds that often form part of a squall or thunderstorm. You may see lightning but hear no thunder if the storm is too far away.

Try to note any increase in wind speed, increase in sea conditions, or shift in wind direction that may be occurring. If you are enjoying yourself in a protected anchorage this will often not be readily apparent. A judicious weather eye may save you an uncomfortable ride home.

Local Weather Conditions

You may have noticed that during the warm season an afternoon breeze will very often come up to cool you and provide good sailing weather. You have probably wondered what the reason for this is.

The sun heats the land and sometime during the late morning or afternoon, a "sea" breeze forms. The heating of the land, if excessive, can cause an unstable condition which was discussed earlier. As warm air rises clouds will form. If the warm air is plentiful and moisture laden, conditions may be right for the formation of a thunderstorm. With sundown the flow halts.

At night, the pattern will be reversed. Water temperature does not vary at all. The air overlying water is relatively warm. It rises a little and cooler air from land areas moves in to fill the space.

Thunderstorms

This weather is of particular concern to boatmen because of the rain and lightning and also because of squalls or sudden violent winds that often accompany it. Individual storms cannot be predicted with great accuracy and are capable of forming in hours. We will describe a typical storm and see how it forms.

It is a hot summer day. The weather forecast warns of "widely scattered afternoon thundershowers." As you depart on your boat at noon it is a beautiful day with light breezes and a few puffs of cumulus clouds floating by.

During the day the land has been heated and the sea air has been blown landward. The moist air becomes warm and rises forming clouds. With a continuing supply of this air, clouds will grow larger and rise higher.

From aboard your boat you notice larger clouds forming nearby. One cloud in particular has great upward development growing higher and larger and giving the appearance of a misshapen cauliflower.

This cloud has found a supply of hot, moisture laden air and is growing at a rapid rate. Near the top, which may be 25,000 ft., moisture is condensing and forming ice crystals. When a certain amount of moisture has condensed it falls towards the earth as rain or even hail and snow. The falling precipitation causes a "chute" to form in the center of the cloud. The wind velocity in this area is high because of the coolness of the air and the weight of its moisture. When these high winds strike the surface of the water they produce squalls accompanied by heavy pelting precipitation.

Your observation indicates that the cloud has continued to grow. It rises to an altitude where the winds are stronger and begins to assume an "anvil" shape as the top of the cloud flattens out. The higher the cloud, the more severe its storm will be. The storm cloud moves in the same direction as other clouds. The direction is indicated by the point of the anvil. A dark area of rain is visible under the middle of the cloud. You see the flash of lightning and hear the clap of thunder off in the distance. Incidentally, the distance between you and the storm, can be estimated by multiplying the seconds that elapse between a flash of lightning and a clap of thunder by 0.2. A five second delay would mean that the storm is about 1 mile away.

As the storm approaches you, a low threatening black cloud rolls toward you. As this cloud approaches you notice that white objects such as sails and boat hulls appear to have a bright, almost fluorescent appearance. Suddenly the wind dies completely and you think perhaps the storm has passed over. Suddenly, you are hit with a gust of wind and a driving rain. The rain is so heavy that visibility is reduced to near zero and even your windshield wipers are inadequate. This continues for a few minutes and then the rain and wind gradually stop. Soon the storm passes and the sky clears. A sudden storm is very exciting but it can also be very dangerous. Squalls can have winds of 30-40 or more knots and will stir up very steep, choppy seas.

Be weather prudent. Keep your eyes open—particularly if the weather forecast contains a word of warning. Watch for clouds that are building rapidly in height. Listen for static on your radio. If you think there's a good chance of thunderstorms, do not venture too far from protected waters.

If it appears you are going to be caught in the approaching storm, make your way to the nearest safe anchorage and ride it out at anchor. Button up any covers you may have, to keep out some of the rain. Stay away from any objects that may provide a path for lightning. Turn on your anchor light so

other people can see you. The storm will probably last only a few minutes; but it may give you a rough ride and a severe drenching while it does.

Sources for Further Study

Weather is a very interesting topic. We have covered only the basics here. If you are interested in going deeper into the subject, the following references are suggested:

Weather for the Mariner, W. J. Kotsch, U. S. Naval Institute.

Weather, H. S. Zim, P. E. Lehr, R. W. Burnett, Golden Press. A good book for those who want easy reading.

Weather, Water, and Boating, D. A. Whelpley, Cornell Maritime Press. A very readable book written in boatman's language.

Meterology, W. L. Donn, McGraw-Hill.

CHAPTER 12

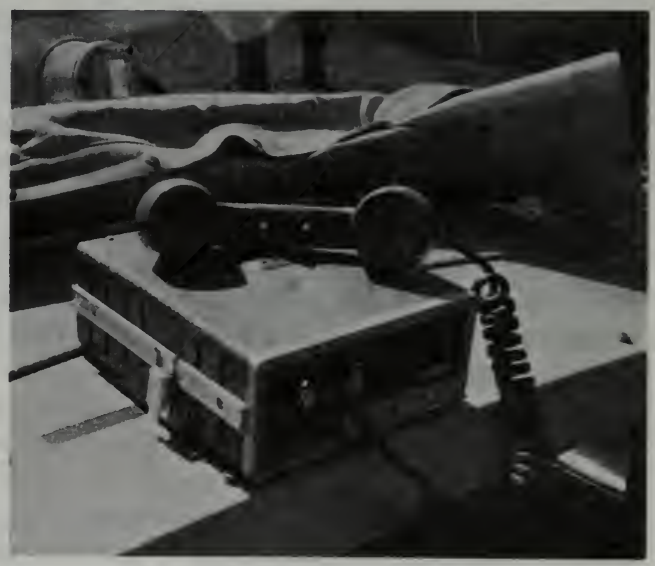
Radiotelephone

Introduction

The modern marine radiotelephone is unquestionably one of the most important items of safety equipment available to owners of pleasure craft, and you are well-advised to purchase an efficient radiotelephone for your boat if you do not already have one. While a radiotelephone can often be a convenience in the sense that you can communicate with other craft or with the shore, its principal purpose is safety. If you encounter difficulties while underway, your call for assistance on your radiotelephone may make the difference between inconvenience and disaster. At all times, day and night, there are many radio stations listening on assigned frequencies for distress calls from mariners in trouble. These include Coast Guard Stations and vessels, merchant ships, many coastal commercial stations and many small craft. So, if your radiotelephone is operating properly, it is almost a certainty that your call for assistance will be heard.

What is a Radiotelephone

A radiotelephone is actually a small radio station. It is similar to a commercial station in the sense that signals transmitted by your radiotelephone can be heard by any radio receiver which is within range and is tuned to the same frequency. It differs from a commercial radio station in that a commercial station broadcasts only. Your radiotelephone has the capability of receiving as well as transmitting, hence the designation "radiotelephone." Since any station within range can receive your messages, these messages become, in a sense, public. For this reason you must be more careful about what you say over the air than you might be in a private conversation over your phone at home.



12-1 Radiotelephone Set

If yours is a pleasure craft, and you do not carry paying passengers, you are not legally required to have a radiotelephone aboard. If you install a radiotelephone on your boat, it becomes what is technically known as a "voluntarily equipped vessel." But even though you are voluntarily equipped with a radio-telephone, you are still obliged to comply with certain rules and regulations.

All nongovernment radio stations in the country (including your radiotelephone) fall under the jurisdiction of the Federal Communications

Commission. The FCC has issued a code of rules which regulate (among other things) the stations themselves, the operators, the format and content of transmissions and the frequencies to be used. In addition, The FCC has been empowered to enforce these regulations by warnings, revocation of licenses, fines, and, in some cases, imprisonment. So—when you buy that brand new radiotelephone you become involved immediately with a whole new body of law.

Later on in this chapter we will discuss the rules and regulations which apply to you and your radiotelephone. We will also discuss proper operating procedures. But, before we do this, let's take a look at the frequencies available and the systems in use on these frequencies.

The Two Radiotelephone Systems

There are two voice communications systems available to marine users which are designed to meet the dual requirements of safety and utility. Both systems permit communications between vessels and between ship and shore. They are commonly referred to as the 2-3 MHz system and the VHF-FM (156-174 MHz) system. Multiples of 1,000 cycles are written as kHz (Kilohertz) and multiples of 1,000,000 cycles are written as MHz (Megahertz). This new unit honors Heinrich Hertz, an early pioneer in radio.

The 2-3 MHz System

The International Distress and Calling Frequency, 2182 kHz, is the keystone of the 2-3 MHz band radiotelephone system. This medium range frequency is widely guarded and the chances of being heard in an emergency are usually excellent. The other frequencies available for use on this band have the same characteristics of relatively long range, although severe congestion exists in many areas. This band is badly affected by both natural and man-made interference. Range is dependent on the rf output of the set; the greater the rf power output, the greater the range. In addition, the 2-3 MHz frequencies themselves have a characteristic known as "long distance propogation," which, at night, can cause interference with other stations well beyond the normal operating range of the set. Thus, undisciplined use of the radiotelephone after dark may cause a nuisance over a comparatively large geographic area.

Frequencies available to the 2-3 MHz system and their use are:

Frequency	*Use*	*Areas*
2003 kHz	Ship-to-ship	Great Lakes area only.
2142 kHz	Ship-to-ship	Pacific area south of 42°N, on a daytime basis only.
2182 kHz	Distress, Safety, Calling	All areas.
2638 kHz	Ship-to-ship	All areas.
2738 kHz	Ship-to-ship	All areas except the Great Lakes and the Gulf of Mexico.
2830 kHz	Ship-to-ship	Gulf of Mexico only.

In addition to the above, certain frequencies are assigned for handling public correspondence or telephone messages with the shore.

The VHF-FM (156-174 MHz) System

The channel used for distress and calling is channel 16 (156.8 MHz). This channel is the key stone of the VHF-FM band (156-174 MHz) maritime mobile radiotelephone system. Channel 16 is guarded by Coast Guard ship and shore stations, many municipal agencies and an increasing number of merchant vessels and pleasure craft. Minimum interference from other stations and reduced noise levels are notable advantages of this system. Frequency modulated systems (as is this system) are relatively unaffected by natural and man-made interference. This often means more effective communications. Very high frequency (VHF) radio waves travel in a straight line and will not "bend" or reflect over the horizon. This limits VHF communications to a maximum of about 40 miles. However, range is very much dependent upon the height of the transmitting and receiving antennas. rf output is limited to 25 watts, and a switch to limit output to 1 watt is required for short range harbor communications. For non-government use there are 38 communication and 2 weather channels on this band, VHF-FM (the 156-174 MHz band) will become the primary communications system for all-short range communications.

Channels available to the VHF-FM (156-174 MHz) system and their use are:

Channel designator	Frequency (MHz)		Points of communication
	Ship	Coast	
Distress, Safety and Calling			
16	156.800	156.800	Intership and ship to coast.
Intership Safety			
06	156.300	156.300	Intership.
Port Operations			
65	156.275	156.275	Intership and ship to coast.
66	156.325	156.325	Do.
12	156.600	156.600	Do.
73	156.675	156.675	Do.
14	156.700	156.700	Do.
74	156.725	156.725	Do.
20	157.000	161.600	Do.
Navigational			
13	156.650	156.650	Intership and ship to coast.
Environmental			
15	----------	156.750	Coast to ship.
State Control			
17	156.850	156.850	Ship to coast.
Commercial			
07	156.350	156.350	Intership and ship to coast.
67	156.375	----------	Intership.
08	156.400	----------	Do.
09	156.450	156.450	Intership and ship to coast.
10	156.500	156.500	Do.
11	156.550	156.550	Do.
77	156.875	----------	Intership.
18	156.900	156.900	Intership and ship to coast.
19	156.950	156.950	Do.
79	156.975	156.975	Do.
80	157.025	157.025	Do.
88	157.425	----------	Intership.
Noncommercial			
68	156.425	156.425	Intership and ship to coast.
09	156.450	156.450	Ship to coast.
69	156.475	156.475	Do.
70	156.525	----------	Intership.
71	156.575	156.575	Ship to coast.
72	156.625	----------	Intership.
78	156.925	156.925	Ship to coast.
Public Correspondence			
24	157.200	161.800	Ship to public coast.
84	157.225	161.825	Do.
25	157.250	161.850	Do.
85	157.275	161.875	Do.
26	157.300	161.900	Do.
86	157.325	161.925	Do.
27	157.350	161.950	Do.
87	157.375	161.975	Do.
28	157.400	162.000	Do.

Selection of VHF-FM Channels

There are so many channels available that you may be puzzled as to which ones to install in your set. Here is the reasoning to use in such selection. Every ship must have Channels 06 and 16. No matter what ship you call or answer, you can shift from 16 to 6 to exchange information. Channel 06, however, should be reserved for important, "safety" communication and not used for routine business between vessels.

Channel 68 is the universal small boat channel. It may also be used by coast stations at yacht clubs and marinas. Two other channels, 70 and 72, are limited to non-commercial (yacht) intership communication. It would be good to have one of these perhaps picking 70 as the first choice. Channels 69, 71 and 78 are also non-commercial but intended only for ship to coast. These would most likely be used by a particular yacht club which wishes to have an almost private channel for its own use. These channels should not be installed unless you belong to such an organization.

Channel 09 is the one frequency that is both commercial and non-commercial. Consequently it is most used by docks, boat yards, marinas and businesses to contact ships. It is important that you have this channel.

There is no universal channel for Port Operations but most Coast Guard stations use Channel 22 (Government-non government liaison channel). Therefore it is one of the channels you would be able to switch to in order to work a Coast Guard radio station after initial contact on Channel 16.

There are nine channels for "Public Service" usage, which means to make calls to shore telephone numbers. You should install those that will be used in your boating area.

There are two continuous weather broadcasting channels. The one in your area should be installed.

To summarize, a good choice of channels would be as follows:

Channel	*Usage*
16	Calling and distress.
06	Intership safety.

68	Working channel between yachts and from a yacht to a marina or club.
09	Working channel for yacht to dock or marina.
22	Working channel for contact with Coast Guard or for Port Operations.
*	Public Correspondence (Telephone calls)* determine local channel
WX	Continuous weather broadcasts.

As the VHF-FM system grows, you will want more channels. A set with 12 channels will supply sufficient room to expand.

Functions

The 2-3 MHz and the VHF-FM (156-174 MHz) radiotelephone systems each provide for three basic communication functions. In their order of priority, these are:

SAFETY—OPERATIONS—BUSINESS

Safety Function

The safety function is provided by internationally designating one frequency from each system for safety communications between all stations. The designated safety frequencies (distress and calling frequencies) are used for calling and answering to insure that a maximum number of stations stand watch on these frequencies. Provision has been made in the 2-3 MHz system, and in the VHF-FM system, for shore station broadcasts of weather reports, notices to mariners and other information necessary for the safety of navigation.

Operations Function

The operational function is concerned with the exchange of information pertaining to navigation, movement, or management of vessels.

Business Function

The business function is concerned with economic and commercial matters related directly to the purpose for which the vessel is used.

How Your Radiotelephone Works

Your radiotelephone is different from your phone at home or office in one principal feature. On your home phone both parties can (and often do) talk at the same time, with the louder voice usually emerging triumphant. On your shipboard radiotelephone this is not possible. Your station consists of a transmitter and a receiver, using a common antenna. Your transmitter is controlled (usually) by a "push-to-talk" button or switch on the microphone. When this switch is depressed, the transmitter circuit is engaged and the receiving circuit is disengaged. When the "push-to-talk" button is released, the receiver is engaged and the transmitter is not engaged. So, on your radiotelephone you can either transmit or receive, but you cannot do both at the same time.

After you have called another station you must release the microphone switch before you can hear the other station's reply. The operator of the other station must, in turn, release his microphone switch before he can hear your reply to his transmission. If both stations transmit at the same time, neither can hear the other because the receiving circuits of both stations are disengaged.

How The Systems Should Work

Technically, your boat's radiotelephone is known as a Maritime Mobile Station. FCC Rules clearly stipulate that all Maritime Mobile Stations must maintain an efficient listening watch on either 2182 kHz or Channel 16 at all times while the station receiver is turned on and the station is not being used for communications on another frequency. Absolute priority must be given to distress and other safety communications and you may use your radiotelephone only for transmissions which are of a type authorized by the FCC. Because others are waiting to use the frequency, all transmissions except those involving distress or safety should be as brief as possible.

Communications between vessels, or between vessels and the Coast Guard, are usually initiated on 2182 kHz or Channel 16. The initial call is answered on this frequency and except for communications with Coast Guard stations, both stations then shift to an appropriate intership or working frequency. Before transmitting on any frequency, you should listen on that frequency for

12-2 Coast Guard Communication Station

a while to be certain that others are not using the frequency, or that no distress or safety traffic is in progress. All Maritime Mobile Stations must give their call sign at the beginning and end of each communication with another station and at the beginning and end of any transmission made for any other purpose.

The Present Situation

The system of itself works beautifully. Unfortunately, human beings are involved and here is where the problem lies. Boatmen (and even the radio operators of large vessels) do not always listen on the assigned frequencies. Long-winded conversations clutter up the airwaves. Boatmen with powerful radios and weak minds often interrupt distress traffic and may drown it out completely. As a result the safety feature, which was the principal purpose for the establishment of the system, has been degraded by disorder and confusion to the point where a vessel in distress may be unable to get help because of the clutter on the frequencies. The serious and disastrous consequences of irresponsible and undisciplined use of the system are clearly illustrated by the PELICAN incident, which occurred off Montauk Point, New York. . . .

The following is from a statement by the captain of one of the assisting craft concerning his part in the rescue operations. "While coming around Montauk Point in a NE gale we saw a fishing boat turn over in the rips off Montauk Point. We were three-fourths to one mile offshore of this boat—immediately started to go to her assistance and called for help on our radio. I had a 35 watt set in good condition on this boat, and got some surprise when I found I could not get a message through on account of a pleasure boat inviting company aboard to celebrate that they were out of the blow, and a commercial boat thinking that he better forget fishing on account of the wind. All this took at least fifteen minutes, until the SUNBEAM, a Niantic fishing boat, picked up the message and with his more powerful radio set finally cleared the air and I was able to direct the rescue boats to the position of the accident. The pleasure boat refused to get off the air and the commercial boat talked too long about nothing at all. The result of the accident was 37 dead, 19 saved."

What the Future Looks Like

In order to alleviate some of the problems noted above, all short range marine radiotelephone communications are being shifted from the 2-3 MHz-AM band to the VHF-FM (156-174 MHz) band. As stated before, this band has 38 communication and 2 weather channels. Longer range communications (other than high seas radio) will remain on the 2-3 MHz band, employing single sideband emissions. Single sideband is a more efficient form of communication than conventional AM double sideband. By eliminating the second sideband of the transmitted signal and removing the carrier, all of the rf output power can be concentrated in one sideband for more effective communications. Single sideband provides greater range, eliminates detrimental fading and, because of the narrower bandwidth, improves the signal-to-noise ratio. Under adverse conditions SSB communications can be as much as eight times as effective as conventional AM double sideband.

Starting January 1, 1972, 2-3 MHz AM double sideband sets will not be licensed, but ship stations licensed prior to that date may continue to use them until January 1, 1977. After this only VHF-FM will be permitted for short range communication. Those boats needing longer range communications may install a 2-3 MHz SSB set if a VHF-FM set is also installed and used for short range contacts.

The Citizens Radio Service

The past several years have seen an increased tendency on the part of owners of small craft to equip their vessels with radios which operate on the "Citizens Band" (26.965-27.255 MHz-AM). This is the Class D Citizens Radio Service, which is available to the general public; the only restriction being that its licenses are available to American citizens only. This band is crowded with over 700,000 licensees having approximately 3,000,000 radios. This crowded condition is further complicated by the growing tendency of Citizens Band licensees to imitate the hobbying activities of the Amateur Radio Service.

The Citizens Radio Service was established to provide a service for both business and personal use where other means of communication were not available.

The Citizen's Radio Service has several serious disadvantages compared to the maritime mobile frequencies (2-3 MHz and 156-174 MHz):

1. There is no distress or calling frequency.
2. The Coast Guard is not equipped with Citizen's Band radios and therefore cannot hear a call for help.
3. No broadcasts are made of emergency weather or marine information.
4. No vessels are required to install or monitor Citizen's Band Radios.

The Coast Guard in no way supports or encourages use of the Citizen's Band for marine safety purposes.

Operating Procedures (Non Emergency)

Even though the principal reason for having a radiotelephone aboard is to assure safety, boatmen may have occasions when they might wish to send a message which is not of an emergency nature. Radiotelephone operating procedures are not difficult to learn. A few simple rules must be followed to assure orderly message traffic over the air.

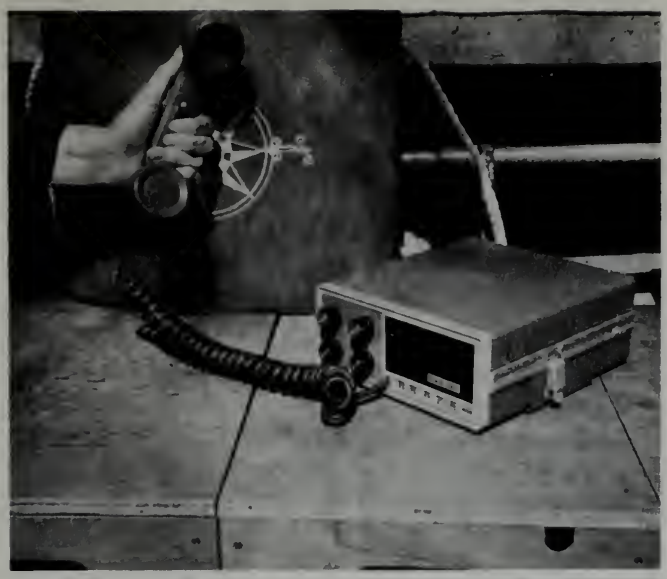
How to Make a Call

The first thing to remember when you are about to make a call on your radiotelephone is that you will be talking on a gigantic "party line." Good manners include not interrupting others who may already be using the channel, except in an emergency.

Let's assume you wish to make a call on your VHF-FM radio to the cabin cruiser MORA-KAI. Your boat's name is the GROVER TWO and your call sign is WM4154.

1. Turn on your set and listen to channel 16 for a few minutes. If you hear others talking, wait until they are through.
2. When the channel is clear, depress the "push to talk" button on the microphone, hold the mike a few inches from your mouth and say in a normal tone:

   THE MORA KAI, THE MORA KAI, THIS IS THE GROVER TWO, WHISKEY MIKE FOUR ONE FIVE FOUR, OVER.



12-3 Hand Set with "Push-To-Talk" Switch

3. Release the "push to talk" button and listen for MORA KAI's reply, if MORA KAI does not reply, you may repeat the above call three times at intervals of two minutes each. If there is no reply after the third call, calling shall cease and shall not be renewed until after an interval of 15 minutes. Each attempted call shall not exceed 30 seconds in length.

4. If MORA KAI does reply, he will say:

   GROVER TWO, THIS IS THE MORA KAI, WHISKEY ZULU YANKEE ONE ONE FOUR THREE SHIFT, CHANNEL SIX EIGHT, OVER.

   MORA KAI has replied and requested that you shift to a working frequency. There are other working frequencies in different geographic areas and MORA KAI could have suggested any available working frequency.

5. You reply:

   THIS IS THE GROVER TWO–WILCO (Will Comply), OVER

6. Both vessels now shift to Channel 68. Before transmitting on this working frequency, wait until others who may be using the frequency are through. You now transmit your message. If you wish a reply from MORA KAI you would use the proword OVER at the conclusion of your message. OVER means that you expect a reply and will remain on the frequency to receive it.

7. On the conclusion of your complete message exchange with MORA KAI (which shall not exceed 3 minutes after making the initial contact), you say:

   THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR, OUT.

   The proword OUT means that this is the end of your transmission and a reply is not expected. Do not say OVER AND OUT as this is contradictory terminology. Either you expect a reply or you don't. If no reply is expected or required, use the proword OUT.

8. Shift the channel selector back to Channel 16 and resume your listening safety watch on this frequency.

9. If your set is 2-3 MHz AM transmitter, the initial call would be made on 2182 MHz, and you would both shift to an agreed working frequency on that band. The voice procedures would be similar to those described above.

10. After your conversation with MORA KAI is complete you shall not establish contact with this same vessel again until at least 10 minutes have elapsed.

11. Note how individual letters are not spoken as such but special words are used for each letter. This is to prevent misunderstanding between many letters which sound alike.

    An International Phonetic Alphabet using designated words for each letter has been developed. This alphabet is shown on the inside back cover. While some of the words may seem strange to us, remember that this alphabet was selected for use by operators speaking other languages as well as English. This alphabet should be memorized and a copy posted near your operating position.

Calls are initiated generally on a calling frequency and shifted to a working frequency. However, many boatmen have developed the practice of arranging in advance with one another to make calls at certain scheduled times. These scheduled calls may be initiated on a working frequency since it is known that the other vessel will be listening on that frequency at that scheduled time. This procedure lessens congestion on the calling frequencies.

Calls to shore stations (such as the telephone company) should be made on that station's working frequency. Telephone company channels are usually divided into two frequencies – the vessel transmits on one frequency and the shore station transmits on another frequency. On your boat you will hear the shore station only. When another vessel is communicating with the shore station, you will hear a signal on that frequency similar to the "busy" signal on your home phone. This signal is transmitted by the shore station when they are receiving traffic and it indicates that "the line is busy." On the other hand some coast stations transmit back over the coast frequency the transmission picked up from the ship. Thus both sides of the conversation can be heard, letting you know that the channel is busy. In any event wait until the frequency is clear before calling the shore station.

How To Receive a Call

You can receive a call on your radiotelephone only if your receiver is turned on and tuned to the frequency on which the sending station is transmitting. The voice procedures described under "HOW TO MAKE A CALL" apply to receiving calls as well as transmitting them. Many boatmen keep an extra radio receiver aboard (a portable radio does very nicely) on which they monitor an additional channel, such as a telephone company transmitting frequency, if they expect a call from their home or office.

"Two channel monitoring" (keeping a listening watch on two channels at the same time) requires a bit of getting used to. At first it may seem confusing but soon you will become proficient at it. Coast Guard vessels and stations, as well as Coast Guard Auxiliary vessels on patrol under orders, normally guard at least two channels at once and more in most cases. It's a good way to keep your radio watch and at the same time listen for calls on another frequency.

Maintain Your Listening Watch

While any radiotelephone is turned on, keep its receiver tuned to the applicable distress frequency, 2182 kHz or 156.8 MHz (Channel 16), and listen so that you may hear any call for assistance. Maintain your distress guard. Remember, others are doing the same thing and will hear you if YOU ever need help. Although your watch on the distress frequencies will be interrupted while you are engaged in activities such as making ship-to-shore calls and copying marine information broadcasts, someone else will still be listening, and the sooner you return to your listening watch on the distress frequencies the larger the listening audience will be.

Also, other stations attempting to call you will almost invariably call you on one of the calling and safety frequencies. If you maintain an efficient listening watch, you will not miss any important messages directed to you.

Test Transmissions

It is a violation of FCC Rules for anyone except an FCC licensed technician to call the Coast Guard for a "radio check." This rule was established to restore a degree of efficiency to the calling and safety frequencies. If you wish to determine whether or not your transmission is "getting out," the easiest way is to call another vessel on a working frequency.

Another method is to make a test transmission. A test transmission is not directed to another station so you must be careful that it will not appear to be a call to another vessel or station. This is done by using a number count or other phraseology which will not confuse listeners. The test is accomplished by observing a light or rf meter on your set. When you talk into the microphone the light will appear to brighten, or the indicator on the meter will deflect. Some boatmen use a small field-strength meter which can be installed in any convenient location on the boat.

Regardless of the method used to visually observe the effect of your transmissions, the test should be conducted along standardized lines. Before testing, as before all transmissions for any purpose, *listen* for a few minutes on the frequency. It's legal to test on any channel but it's best to leave the calling and safety channel clear and do your testing on a working frequency. Assuming you have decided to test on Channel 68, place the transmitter on the air and say:

> THIS IS THE GROVER TWO—WHISKEY MIKE FOUR ONE FIVE FOUR—TEST.

Then listen for a moment before continuing. If no other station tells you to "wait," proceed with your test as follows:

> TESTING, ONE TWO THREE FOUR FIVE—THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR—SIXTEEN MILES DUE WEST OF OCEANSIDE, CALIFORNIA—OUT.

While talking into the microphone, observe your visual indicator, whether it be a light or a meter. If the light brightens with your spoken word or the indicator on the meter deflects appreciably, you will know as much about your radio transmissions as you will ever know. Also, be sure to include your general location at the conclusion of your test transmission.

Getting Your Weather

Have you ever been caught offshore in a sudden blow and had to run for the nearest safe port? As your boat slammed into the waves have you ever wished that you could predict the weather to keep from being out like this? The National Weather Service would like to be of some help to you and you can take advantage of their services free. The Weather Service is constantly updating their short and long range forecasts and the Coast Guard broadcasts this information at regularly scheduled times every day. Generally, a preliminary announcement will be made on 2182 kHz on the 2-3 MHz band and on Channel 16 (156.8 MHz) on the 156-174 MHz band. This announcement will direct you to shift to the frequency on which the weather report will be transmitted.

12-4 Thunderstorm

The National Weather Service in many areas broadcasts continuous weather information from their offices over their own radio stations. This is done on one of the VHF-FM weather channels, either 162.55 or 162.40 MHz. These broadcasts cover marine as well as land based weather needs and are up dated every few hours or so. On some of these stations special safety warnings from the U. S. Coast Guard are also included.

In some areas the phone company broadcasts weather at scheduled times, and this service is also offered by some commercial broadcasting stations. So—since the weather is so easy to get—why do without it? Get your weather at every opportunity, especially in localities where storms come up quickly. Your reputation as a skilled boatman will be enhanced immeasurably as you demonstrate your ability, not only to bring your passengers back alive, but also to bring them back comfortably and dry!

Safety, Urgency and Distress Messages

The marine radiotelephone safety and communications system includes provisions for the transmission of messages which involve marine safety. These messages are preceded by distinctive calls, which are either SECURITY, PAN or MAYDAY.

The Safety Signal

The safety signal consists of the spoken word SECURITY (pronounced SAY-CUR-I-TAY), re-

peated three times before the name and the call sign of the calling station or vessel. It indicates that the calling station is about to send a message concerning safety of navigation or is about to send a message concerning weather. The initial call is transmitted on Channel 16 or on frequency 2182 kHz and, whenever practical, the message is sent on a working (ship-to-ship) frequency. An example of a safety message follows:

On 2182 kHz

"SECURITY, SECURITY, SECURITY–THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR SHIFT TWO SIX THREE EIGHT (or other working frequency) KILOHERTZ FOR SAFETY MESSAGE–THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR–OUT."

On 2638 kHz

"SECURITY, SECURITY, SECURITY–THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR–A FLOATING DRILL MINE HAS BEEN LOCATED FLOATING AT POSITION LATITUDE THIRTY THREE DEGREES FORTY ONE MINUTES NORTH–LONGITUDE ONE HUNDRED EIGHTEEN DEGREES TEN MINUTES WEST–THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR–OUT."

The Urgency Signal

The urgency signal consists of the spoken word PAN (pronounced *Pawn*, to rhyme with *Lawn*), repeated three times before the call sign and name of the calling station or vessel. It indicates that the calling station is about to transmit a message concerning the safety of a vessel or person. This call should be transmitted on frequency 2182 kHz. An example of an urgency message follows:

PAN, PAN, PAN–THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR–POSITION TWO MILES OFF–ON BEARING ONE SIX FIVE DEGREES TO WEST END–CATALINA ISLAND–HAVE RUN OUT OF FUEL–AM DRIFTING TOWARD SHORE AND REQUIRE A TOW–THREE PERSONS ON BOARD–GROVER TWO IS A TWENTY SIX FOOT CABIN CRUISER–WHITE HULL–BLUE TRIM–REGISTRATION CHARLIE FOXTROT EIGHT ZERO FIVE NINER ALPHA WHISKEY–THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR–OVER.

The Distress Signal

As stated before, the principal reason for having an expensive radiotelephone on board is to assure your safety. In an emergency you may send a distress message on either of the calling and safety frequencies, or any other frequency for that matter. The voice-call for a distress is the spoken word MAYDAY repeated three times. It should be mentioned here that a MAYDAY should *not be sent* unless you are in *"grave and imminent danger"* and *immediate* help is required. Unfortunately, there are all too many MAYDAY calls from boats out of fuel and riding comfortably at anchor. Admittedly, running out of fuel can be a frightening experience, especially the first time (and some boatmen seem to do so with regularity) but by no stretch of the imagination could this be considered a situation in which you are in 'grave and imminent danger."

For less serious situations, such as the one described above, a simple call for assistance, explaining your predicament, would do the job very nicely –and achieve the same result without the need to put a MAYDAY on the air.

How to Make up and Transmit a Distress Call

Basically, the distress *call* consists of three distinct parts: The voice call MAYDAY repeated three times; the words THIS IS said once; and the name and call sign of the vessel in distress repeated three times.

The distress *message* consists of ten parts:

1. The voice call MAYDAY.
2. The name and call sign of the vessel in distress.
3. The position of the vessel in distress.
4. The nature of the distress.

5. The assistance required.
6. The present seaworthiness of the vessel in distress.
7. The number of persons aboard and the condition of any injured.
8. The description of the vessel–length, type, color of hull, color of trim and registration numbers.
9. Your radio listening frequency and schedule.
10. Close with your vessel's name and call sign.

It is important to send the information in the order listed above, especially items #1, 2 and 3 of the message. If your radio is in danger of being drowned out, the first three items will identify you and tell others where you are. Then, if your power should fail before the message is completed, you will still stand an excellent chance of being located.

Let's assume you are aboard the GROVER II and the boat has slammed into a floating object causing the hull to spring a leak. Water is rising in the bilge and you cannot find the leak. It's time to get help, so you place your transmitter on the air on Channel 16 or 2182 MHz and prepare to *read* your distress message over the air. It's an excellent idea to write out your message and *read* it. In this manner you stand less chance of leaving things out of your message when it goes out over the air. If you leave pertinent information out of your message, the radio operator will be forced to ask for it, thus wasting valuable time.

MAYDAY, MAYDAY, MAYDAY–THIS IS THE GROVER TWO–WHISKEY MIKE FOUR ONE FIVE FOUR, THE GROVER TWO–WHISKEY MIKE FOUR ONE FIVE FOUR, THE GROVER TWO–WHISKEY MIKE FOUR ONE FIVE FOUR, POSITION APPROXIMATELY SIX MILES OFF–ON BEARING ZERO ONE ZERO DEGREES TRUE–TO DANA POINT–STRUCK FLOATING OBJECT–TAKING WATER–REQUEST COAST GUARD ASSISTANCE–ESTIMATE CAN REMAIN AFLOAT TWENTY FIVE MINUTES–TWO PERSONS ON BOARD– GROVER TWO IS A TWENTY SIX FOOT CABIN CRUISER–WHITE HULL–BLUE TRIM–REGISTRATION CHARLIE FOX-TROT EIGHT ZERO FIVE NINER ALPHA WHISKEY–THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR–OVER.

If the Coast Guard radio operator does call you back and ask for more information, do not become impatient. His job is to get complete information on your case and send it on to Rescue Coordination Center. It's RCC's job to evaluate all available information. In many cases assistance is offered by nearby private, commercial, or municipally-owned vessels. Assistance of this nature has saved many lives, and is utilized whenever feasible. Sometimes this voluntary assistance will be limited to standing by until professional help arrives, but it's reassuring to have another vessel standing off a few hundred feet in the circumstances. RCC could dispatch a regular Coast Guard air or surface unit, or a Coast Guard Auxiliary vessel. In any case, RCC cannot help you until they have all of the information necessary to evaluate the situation. Hence the need for *complete information* in your first call for help.

How to receive a Distress Call

When a MAYDAY is heard, all stations are required to listen on the frequency. If you are *certain* that the vessel in distress is in your immediate vicinity, you should acknowledge receipt of the message immediately. If you are not certain where the distressed vessel is, it's best to wait a minute or so to allow the message to be acknowledged by vessels which may be nearer to the scene. In areas of heavy boating activity, where a Coast Guard Radio Station is nearby, it's good practice to delay acknowledgment of the distress call for a minute or so to allow time for the local Coast Guard station to reply. An acknowledgment of a distress message would be made as follows:

1. The name and call sign of the distressed vessel–three times.
2. The words THIS IS.
3. The name and call sign of your vessel–three times.
4. The words RECEIVED MAYDAY.

Let's assume once again that you are aboard the cabin cruiser GROVER-II, WM 4154. You have copied a MAYDAY from the cabin cruiser CHRIS-LYNN, WZU 3748. You would place your trans-

mitter on the air on the same frequency over which the call was received, and say:

> THE CHRIS LYNN WHISKEY ZULU UNIFORM THREE SEVEN FOUR EIGHT–THE CHRIS LYNN–WHISKEY ZULU UNIFORM THREE SEVEN FOUR EIGHT–THE CHRIS LYNN–WHISKEY ZULU UNIFORM THREE SEVEN FOUR EIGHT–THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR–THE GROVER TWO–WHISKEY MIKE FOUR ONE FIVE FOUR–THE GROVER TWO–WHISKEY MIKE FOUR ONE FIVE FOUR–RECEIVED MAYDAY.

Allow a short interval for stations which might be nearer to the distressed vessel to acknowledge. Then transmit your amplifying message. This should consist of:

1. The word MAYDAY.
2. The name and call sign of the distressed vessel.
3. The words THIS IS.
4. The name and call sign of your vessel.
5. Your position.
6. Your speed of approach and your estimated time of arrival on scene.

The amplifying message would be as follows:

> MAYDAY–THE CHRIS LYNN WHISKEY ZULU UNIFORM THREE SEVEN FOUR EIGHT–THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR–WE ARE FOUR MILES OFF–ON BEARING ZERO THREE FIVE DEGREES TRUE TO SAN VICENTE LIGHT–NINE MILES FROM YOUR POSITION–OUR SPEED IS FOURTEEN KNOTS–SHOULD ARRIVE ALONGSIDE IN THIRTY NINE MINUTES–THIS IS THE GROVER TWO WHISKEY MIKE FOUR ONE FIVE FOUR–OVER.

General Rules for Distress Messages

The first thing to remember is that a distress call may be sent legally *only* under conditions of grave and imminent danger. Many boatmen have used the international distress call to precede routine messages for assistance not involving imminent danger, and have been surprised when they were cited later by the FCC.

When your life is at stake, keep in mind that you will stand a far better chance of getting help if you follow correct message procedures. However, you may legally use any means at your disposal to get assistance.

Initiate your original call on Channel 16 or on frequency 2182 kHz. If you do not receive a reply after several calls, shift to another frequency.

Don't get excited on the air. Remember, it's best to write your message first, then read it over the air. Speak slowly and distinctly, and spell out any names that might be unfamiliar to others.

If you are asked for a short count, count to five and back slowly and distinctly. If asked for a long count, count to ten and back. The reason for a count is to allow another station to get a radio bearing on your vessel and thus determine your approximate position.

If you have a double side band AM transmitter or VHF-FM transmitter and are forced to leave the vessel before help has sighted you, lock the transmitter on the air by tying down the "talk" button on the microphone before abandoning ship. Your carrier will be useful in helping search vessels locate you.

This procedure will not work on a single side band transmitter since there is no carrier wave.

If you hear a distress message and are unable to assist, listen to the message and copy all pertinent details since you might be requested to relay the message if it is not being received satisfactorily by a Coast Guard radio station or by other vessels near the scene.

Don't interfere with distress traffic in progress. It's unlawful to interfere willingly with any radio communication, especially distress traffic. Also, don't transmit meaningless offers of assistance. If you are not able to assist–STAY OFF THE AIR!

Principal FCC Regulations Governing Voluntarily-Installed Radiotelephone Stations

For the benefit of the beginner-boatman, the principal rules and regulations which apply to voluntarily-equipped vessels are paraphrased here. The student is cautioned, however, that the maritime radio service is changing constantly. Because this is so, the rules under which it operates must

be modified as conditions change. You are advised to compare the continuing accuracy of the material contained herein against a current edition of the complete regulations. These are contained in Part 83 of the FCC's Rules and Regulations Volume IV.

Much of the information already discussed is necessarily repeated in this section. It will act as a good review. Every student should read the regulations carefully. Failure to know them or to observe them could be costly in terms of human life in the event of an emergency.

Station License

A radio station may not be operated except under and in accordance with a valid station authorization issued by the Federal Communications Commission. A station license may be granted, except to an alien, on submission of a properly completed formal application.

The station license is required to be conspicuously posted at the principal operating location on board the vessel. Only FCC type accepted equipment described in the Commission's Radio Equipment List is authorized to be used.

Appropriate application forms may be obtained from any of the FCC field offices listed in Appendix I. Your nearest FCC field office will advise you whether the transmitter you propose to use is acceptable for licensing in the Maritime Mobile Service, if you furnish the manufacturer's name and the model or type number of the transmitter.

Application for a regular-term (usually 5 years) ship radiotelephone station license must be made on FCC Form 502 for the radiotelephone frequencies in the bands 1.6-4 MHz (MF), 4-23 MHz (HF), and 156-158 MHz (VHF). Your application must be (1) accurate and complete (2) accompanied by the appropriate fee, and (3) signed. Except when an Interim Station License is desired, as explained in the following paragraph, send your station license application direct to the Federal Communications Commission, Gettysburg, Pennsylvania 17325.

Frequently, the applicant wishes to obtain necessary authority to use his ship radiotelephone station while awaiting action by the Commission on his formal application. To meet this need, the applicant may immediately obtain an Interim Ship Station License by appearing in person at his nearest FCC Field Office and filing an acceptable formal application (FCC Form 502) with an informal request for an Interim Station License. This license, valid for 6 months from the issuance date, permits the applicant to operate his ship radiotelephone station while awaiting receipt of a full-term station license. An Interim Station License will not be renewed, unless otherwise directed by the Commission in exceptional circumstances.

Application for renewal of the full-term station license (FCC Form 405-B) should be made within 90 days but not later than 30 days before its expiration date. When the licensee has made timely application for renewal of license, the existing license shall continue in effect until the licensee is otherwise notified by the FCC. A ship station licensee operating his station by virtue of the foregoing automatic provisions after the expiration date specified in the license shall post with the expired station license, either a signed copy of the renewal application or a statement certifying that the licensee has mailed or filed a renewal application and showing the date of mailing or filing.

If you permanently discontinue operation of the ship station described in the station license issued to you, as, for example, if you sell your boat, you are required to promptly return the station license to the Secretary, FCC, Washington, D.C. 20554. In the event the license is not available for this purpose, send a telegram or letter to the Secretary stating the reason why the license is not available and requesting that the license be canceled. Otherwise, since the license is in your name, any violations committed in the operation of the station after it has left your control may be your responsibility.

Operator License

Except for safety communications, only a person holding the proper class of valid operator license or permit issued by the Commission is authorized to actually operate a radiotelephone station on board a boat of U.S. registry. The licensed operator, if authorized by the station licensee or an agent thereof, may permit any person to speak into the station microphone, provided he insures operation of the station is in compliance with governing law and regulations.

For operation of the usual radiotelephone ship station, only a Restricted Radiotelephone Operator Permit is required. This permit may be obtained by U.S. citizens and nationals without examination, but the applicant must be able to declare on the application form (FCC Form 753-A) that he is familiar with the applicable FCC rules. Submit the properly completed application and appropriate fee to the FCC, Gettysburg, Pennsylvania 17325.

All adjustments or tests of the radiotelephone transmitter during or coincident with the installation, servicing, or maintenance of such apparatus which may affect the proper operation of the station must be performed by or under the immediate supervision and responsibility of a person holding a First-Class or Second-Class Commercial Radio Operator License (either radiotelephone or radiotelegraph), who shall be responsible for the proper functioning of the station equipment.

The Restricted Radiotelephone Operator Permit must be either posted in a conspicuous place at the principal location on board ship at which the station is operated (i.e., with the station license) or kept on the operator's person. All other classes of radio operator licenses must be posted with the station license while the licensee is employed or designated as radio operator of the station.

Distress and Calling Frequencies

For ship radiotelephone stations operating in the MF band, the distress and calling frequency is 2182 kHz. All stations operating in this band must maintain an efficient listening watch on 2182 kHz at all times while their station receiver is on and is not being used for communication on another frequency.

For ship radiotelephone stations operating in the VHF band, the distress, calling, and safety frequency is 156.8 MHz (Channel 16). An efficient listening watch is required on this frequency at all times while the station receiver is on and is not being used for communication on another frequency.

Use of Distress Frequency and Calling Frequencies

The operational use of 2182 kHz and 156.8 MHz (Channel 16) is restricted to:

(i) Distress signal MAYDAY, followed by distress message;

(ii) Urgency signal PAN, followed by a very urgent message directly concerning safety;

(iii) Safety signal SECURITY, followed by a brief message concerning the safety of navigation or important meteorological warning;

(iv) Call to a particular station, and reply to a call;

(v) Brief radio operating signals (such as agreeing on the channel to be used for exchanging message traffic).

Calling a particular station shall not continue for a period of more than 30 seconds in each instance. If you do not hear the called station reply, do not call that station again until after an interval of 2 minutes. When a station called does not reply to a call sent three times at intervals of 2 minutes, cease calling and do not renew calling until after an interval of 15 minutes. These limitations do not apply in the event of an emergency involving safety.

Except when other operating procedure is used to expedite safety communication, ship stations, before transmitting on an intership working frequency, shall first establish communication with each other by call and reply on 2182 kHz or 156.8 MHz (Channel 16). However, when the calling station knows that the called station is maintaining a simultaneous listening watch on 2182 kHz or 156.8 MHz (Channel 16) and on an authorized intership working frequency, it may initiate calls on such working frequency.

After establishing communication with another station by call and reply on 2182 kHz or 156.8 MHz (Channel 16), ship stations shall change to an authorized intership working frequency for the exchange of messages.

Ship-To-Ship Working Frequencies in the MF and VHF Bands

The following frequencies are currently assigned for intership "working" primarily for safety communication and secondarily for operational and certain business purposes in the MF band:

(1) 2003 kHz, for use exclusively in the Great Lakes area;

(ii) 2082.5 kHz, all areas (single sideband only);

(iii) 2142 kHz, Pacific Coast area south of latitude 42° N., on a day only basis;

(iv) 2203 kHz, Gulf of Mexico (single sideband only);

(v) 2638 kHz, for use in all areas;

(vi) 2738 kHz, for use in all areas except the Great Lakes and the Gulf of Mexico;

(vii) 2830 kHz, for use in Gulf of Mexico.

The following frequencies are currently assigned for use in all areas by noncommercial vessels in the VHF 156-162 MHz band:

(i) 156.3 MHz (Channel 6) for intership safety (this frequency is mandatory);

(ii) 156.8 MHz (Channel 16) for Distress, Safety, and Calling (this frequency is mandatory);

(iii) 156.425 MHz (Channel 68) for intership and ship-to-coast use (subject to the conditions of use in Section 2.7 of this chapter);

(iv) 156.525 and 156.625 MHz (Channels 70 and 72) for intership use only (subject to the conditions of use in Section 7 of this chapter);

(v) 156.450 MHz (Channel 9) for intership and ship-to-coast use (shared with commercial vessels).

Other intership and ship-to-coast channels are available for limited purposes such as Port Operations.

Use of Ship-To-Ship Working Frequencies in the MF and the VHF Bands

Use of the intership "working" frequencies in the MF band (see Section 2.5 of this chapter) is authorized solely for communications pertaining to safety, operational, and ship business purposes. Permissible use is further limited according to the class of vessel, as explained hereunder.

The PRIMARY use of these intership frequencies by all ship radiotelephone stations is for safety communication defined as follows:

Safety communication: The transmission or reception of distress, alarm, urgency, or safety signals, or any communication preceded by one of these signals, or any form of radio communication which, if delayed in transmission or reception, may adversely affect the safety of life or property.

On a SECONDARY basis, on condition that interference is not caused to safety communication, these intership frequencies may be used:

(i) By commercial boats and by commercial transport vessels of municipal or State governments, for OPERATIONAL COMMUNICATION, that is, for radio communication concerning the navigation, movement, or management of a ship or ships. These terms are defined as follows:

NAVIGATION: Includes the piloting of a vessel.

MOVEMENT: Includes information and necessary communication relative to when and where the boat or ship will move or be moved as, for example, rendezvous at a port, basin, or marina, or for maneuvers during a cruise.

MANAGEMENT: Includes the obtaining of necessary supplies for the ship, limited to immediate needs, and the scheduling of repairs or modifications to the ship, limited to communication with those directly involved in the repairs or modifications or concerned with changes in the movement of the ship because of those repairs or modifications.

Noncommercial intership frequencies in the VHF band (see Section 2.5 of this chapter) are subject to the following conditions of use:

(i) 156.425 MHz (Channel 68), available to fulfill the wide scope of needs of noncommercial boats in cases where the number of channels available is limited (this frequency, however, may not be used in lieu of frequencies allotted for Distress, Safety, and Calling, Intership Safety, Navigational, Port Operations, or Public Correspondence).

(ii) 156.525; 156.625 MHz (Channels 70 and 72), available on an interim basis, for noncommercial intership communications during localized fleet operations, maneuvers during a cruise, and rendezvous.

Time Limitation for Communications on the Ship-To-Ship Working Frequencies in the MF Band

Any one exchange of communication between any two ship stations on an intership working frequency (see Section 2.5 of this chapter) shall not exceed 3 minutes in duration after the two stations have established contact by calling and answering.

Subsequent to such exchange of communications on the intership working frequencies in the MF band, these frequencies shall not be used again for communication between the same two stations until 10 minutes have elapsed.

The foregoing time limitations are not applicable in the event of an emergency involving safety.

All transmissions on an intership working frequency between two or more stations, engaged in any one exchange of signals or communications with each other, shall take place on only one frequency (i.e., the stations involved shall transmit and receive on the same frequency). This requirement, however, is waived in the event of an emergency whenever interference or limitation of equipment prevent use of this method of single-frequency communication.

When you cannot use VHF and must use MF, remember that you share the MF radiotelephone frequencies with approximately 150,000 other U.S. ship stations. In addition, some of these frequencies are shared with foreign ship radiotelephone stations. It is obvious that unless each one of the army of users of these "party lines" exercises restraint and intelligence, the circuits can easily be reduced to an intolerable confusion and made useless for their legitimate purposes. Because of the propagation characteristics of these frequencies, your transmissions may seriously interfere with other stations thousands of miles away, even though you are not able to contact or are not plainly heard by another relatively close station with which you wish to communicate. The only solution, other than transferring your operations to the VHF band, is to (1) use your transmitter only when necessary and only for authorized types of communication, (2) use the lowest power required for the particular contact, (3) keep your transmissions short, (4) announce your call sign clearly, and (5) habitually treat other users with courtesy.

Test Transmission Procedure

Transmission of the radiotelephone alarm signal for testing purposes is not authorized. Other transmissions made for testing purposes must be kept to a minimum but are authorized when necessary and when properly conducted.

Always make sure by careful listening that the proposed test emissions will not cause interference. All test transmissions must be preceded by announcing the station call sign followed by the word **TEST** as a preliminary warning. If as a result of such announcement, any station transmits by voice the word **WAIT** suspend testing.

After an appropriate interval of time, you may repeat the test announcement; if there is no response and careful listening indicates that harmful interference would not be created, the test may proceed as follows:

Announce the word TESTING, and follow with a count "1, 2, 3, 4, etc.," or test phrases or sentences that do not conflict with normal operating signals. The test signals shall not last longer than 10 seconds. At the conclusion of the test, make a voice announcement of the official call sign of the testing station. Do not repeat this transmission on 2182 kHz or 156.8 MHz (Channel 16) until at least 5 minutes have elapsed; on other authorized frequencies, do not repeat until at least 1 minute has elapsed.

Station Identification

All transmissions shall be identified by a voice announcement in the English language of the station's call sign. This identification shall be made:

(a) At the beginning and the end of each communication with any other station;

(b) At the beginning and the end of each transmission for any other purpose; and

(c) At intervals not exceeding 15 minutes whenever transmission is sustained for a period exceeding 15 minutes.

When an official call sign has not be allocated to a station, as for example, when a station is operating under an Interim Station License, the complete name of the boat on which the station is located and the name of the licensee must be announced in lieu of a call sign at the times specified above.

Ship Radiotelephone Station Documents

Vessels voluntarily equipped with ship radiotelephone stations shall be provided with the following documents:

(i) A valid station license;

(ii) The necessary operator license or licenses;

(iii) The radio station log;

(iv) Part 83 of the Commission's Rules (may be kept ashore).

Radiotelephone Station Log

A radio log is required; each page must be (1) numbered; (2) bear the name of the vessel and call sign; and (3) be signed by the operator. Make entries showing the time each watch begins and ends. Record as completely as possible all distress and alarm signals, all related communications transmitted or intercepted, and all urgency and safety signals and related communications transmitted. A record of all installations, service, or maintenance work performed that may affect the proper operation of the station must also be entered by the licensed operator doing the work, including his address and the class, serial number, and expiration date of his license.

The 24-hour system is used in a radio log; that is, 8:45 a.m. is written as 0845 and 1:00 p.m. as 1300. Local time is normally used, but Eastern Standard Time (EST) must be used throughout the Great Lakes. Vessels on international voyages use Greenwich Mean Time (GMT) exclusively. Whichever time is used, the appropriate abbreviation must be entered at the head of the time column.

Radio logs must be retained for at least a year, for 3 years if they contain entries concerning distress or disaster, and for longer periods if they concern communications being investigated by the FCC or against which claims or complaints have been filed.

Vessels that are subject to the provisions of (1) Title III, Parts II or III of the Communications Act: (2) the Great Lakes Agreement; or (3) the radio provisions of the Safety Convention must log additional entries (see 83.368(b), (c), and (d)).

Station logs shall be made available for inspection at the request of an FCC representative, who may remove them from the licensee's possession, or on request the licensee shall mail them to the FCC by either registered or certified mail, return receipt requested.

Adjustments

The station licensee shall be responsible for the proper technical operation of his equipment. All transmitter adjustments or tests during or coincident with the installation, servicing, or maintenance of the station that may affect its proper operation shall be made by or under the immediate supervision and responsibility of a person holding a first-class or second-class operator license, who shall be responsible for the proper functioning of the station equipment on completion of his work.

Radio Ground Connection

Effective operation of the usual antenna of ship radiotelephone stations operating in the MF band depends on an adequate radio ground connection. A satisfactory radio ground may be obtained by making a clean and tight connection to the hull of metallic-hulled vessels, with as short a lead as possible for the transmitter ground terminal and using heavy copper wire, strip, braid, or tubing. If the vessel has a nonmetallic hull, it may be necessary to provide a ground connection to a bare plate or strips of corrosion-resistant metal of at least 12 square feet in aggregate area fixed to the hull below the waterline, if connecting to the engine, plumbing, etc., does not suffice.

Secrecy of Communications

Section 605 of the Communications Act of 1934, as amended, prohibits the divulgence of interstate or foreign communications transmitted, received, or intercepted by wire or radio to anyone other than the addressee or his agent or attorney, or to persons necessarily involved in the handling of the communications, unless the sender authorizes the divulgence of the contents thereof. Persons intercepting such communications or becoming acquainted therewith are also prohibited from divulging the contents or using the contents for the benefit of themselves or others.

Obviously, this requirement of secrecy does not apply to radio communications relating to ships in distress, nor to radio communications transmitted by amateurs or broadcast by others for the use of the general public. It does apply, however, to all other communications. These statutory secrecy provisions cover messages addressed to a specific ship station or coast station, or to a person via such station.

Obsenity, Indecency, and Profanity

When two or more ship stations are communicating with each other, they are talking over an extensive party line. Users should always bear this fact in mind and assume that many persons are listening. These listeners include women and children, many of whom regularly monitor the channels in order to hear their husbands or fathers on board vessels at sea. All users therefore have a compelling moral obligation to avoid offensive remarks. They also have a strict legal obligation, inasmuch as Section 1464 of the U.S. Criminal Code makes it a criminal offense for any person to transmit communications containing obscene, indecent, or profane words, language, or meaning. Whoever utters any obscene, indecent, or profane language by means of radio communication shall be fined not more than $10,000 or imprisioned not more than 2 years, or both.

Revocation of Station License

A station license may be revoked for:

(i) Willful or repeated violation of or willful or repeated failure to observe, any provision of the Communications Act or any rule or regulation of the Commission authorized by a treaty ratified by the United States;

(ii) Willful or repeated failure to operate substantially as set forth in the license;

(iii) Violation of or failure to observe any cease and desist order issued by the Commission;

(iv) False statements knowingly made either in the application for license or in any statement of fact which may be required pursuant to such application;

(v) Conditions coming to the attention of the Commission which would warrant it in refusing to grant a license on an original application.

Suspension of Radio Operator License

An operator license or permit may be suspended on proof sufficient to satisfy the Commission that the operator has—

(i) Violated any provision of any act, treaty, or convention binding on the United States, which the Commission is authorized to administer, or any regulation made by the Commission under any such act, treaty, or convention; or

(ii) Transmitted superfluous radio communications or signals or communications containing profane or obscene words, language, or meaning; or

(iii) Knowingly transmitted false or deceptive signals or communications, or a call sign or letter which has not been assigned by proper authority to the station he is operating; or

(iv) Maliciously or willfully interfered with any other radio communications or signals; or

(v) Willfully damaged or permitted radio apparatus or installations to be damaged; or

(vi) Failed to carry out a lawful order of the master or person lawfully in charge of the ship on which he is employed; or

(vii) Obtained or attempted to obtain, or assisted another to obtain or attempt to obtain, an operator's license by fraudulent means.

Monetary Forfeitures (Fines)

In addition to or in lieu of any of the penalties already stated, both the licensee and the person operating the station, if he is not the same person, may be fined for the following offenses:

(i) Operation of a radio station without identifying such station at the times and in the manner prescribed.

(ii) Transmission of a false call sign or a false distress call or message.

(iii) Transmission of unauthorized communications on any frequency designated as a distress frequency or a calling frequency.

(iv) Operation of a radio station so as to interfere with any distress call or distress communication.

The licensee only may be fined for the following offenses:

(v) Operation of a radio station by any person not holding a valid radio operator license or permit of the class prescribed.

(vi) Operation of a radio station on a frequency not authorized by the FCC for use by such station, including operation with a frequency deviation beyond tolerances.

(vii) Failure to attenuate spurious emissions of a radio station to the extent required.

(viii) Operation of a radio station with power in excess of that authorized.

(ix) Use of radio station to transmit unauthorized communications, including those unauthorized for the particular station service.

(x) Operation of a radio station with a type of emission not authorized.

(xi) Operation of a radio station with transmitting equipment not authorized.

(xii) Failure to respond to a written official communication from the FCC.

These fines are imposed for willful or repeated violations of the types enumerated above. The second offense for the same violation is sufficient to constitute a repeated violation. A fine can be as much as $100 for each separate offense. There are certain maximum amounts for multiple offenses within 90 days prior to the date of notice of apparent liability (i.e., $500 for the licensee and $400 for the operator if he is a different person from the licensee).

The FCC completes its legal responsibility for notifying you of these forfeitures when it mails notice to the last address of record. The burden is on the licensee to keep the FCC informed of his latest address. This is important if he wishes to take advantage of any defense procedures provided subsequent to the notice of apparent liability for a forfeiture.

The following has been reproduced from the Auxiliary Communications Text, Revised Edition, Aux. 24-70.

Status of Citizens on Government Vessels

1. DISCUSSION. The Coast Guard policy with regard to Citizens Radio Service operation from Coast Guard units is based on the following considerations:

(a) The Citizens Radio Service was established with the intent of providing a service for both business and personal uses where other means of communication were not available. C-B communication between a government station and non-government station is specifically prohibited except for Civil Defense activities, or in cases involving the immediate safety of life or property. The FCC expressly states that hobby type communications are not permitted. The general intent is that the great majority of communications taking place in this service should be between radio sets belonging to and licensed under one licensee. An example of the aforementioned would be a doctor with citizens band equipment installed in both his home and car.

(b) The Class D band of the Citizens Radio Service is crowded with over 700,000 licensees, and is further complicated by the growing trend of these licenses to imitate the Amateurs. The FCC is taking steps to curtail hobbying activities.

(c) The Citizens Radio Service has become quite popular with the pleasure boat owner. It would be highly probable, were a Citizens Radio Service installation permitted aboard a Coast Guard station, that Coast Guard personnel would be called by and communicate with boatmen about weather conditions, state of the sea, entrance or bar conditions, etc. Such communications would be in violation of the spirit of the clause denying non-government to government use of this service. Further, the Citizens Radio Service has the following limitations when compared with 2182 and 156.8:

(1) No distress or calling frequency.

(2) No watch requirements.

(3) No restriction on type of stations in the service.

(4) No interference protection.

(5) Operators are not required to be licensed.

(6) No emergency broadcasts.

(7) Short range.

Considering the above, it is imperative that the general public be in no way led to believe that the Coast Guard supports Citizens Band for safety purposes.

2. POLICY. Inasmuch as Citizens Radio Service operation is not permitted from the Coast Guard units, facilities of the Coast Guard Auxiliary will not operate on the Citizens Radio Service band when under official Coast Guard orders, except as noted in paragraph 1 (a) above.

Summary of Radiotelephone Operating Practice

1. A licensed radio operator should remember that the station he desires to operate must be licensed by the Federal Communications Commission. In order to prevent interference and to give others an opportunity to use the airways he should avoid unnecessary calls and communications by radio. He should remember that radio signals normally travel outward from the transmitting station in many directions and can be intercepted by unauthorized persons.

(a) Before making a radio call the operator should listen on the communications channel to insure that interference will not be caused to communications which may be already in progress. At all times in radio communications the operator should be courteous.

(b) Station identification should be made clearly and distinctly so that unnecessary repetition of call letters is avoided and to enable other stations to clearly identify all calls.

(c) An operator normally exhibits his authority to operate a station by posting a valid operator license or permit at the transmitter control point.

(d) While a radio transmitter is in a public place it should at all times be either attended by or supervised by a licensed operator or the transmitter should be made inaccessible to unauthorized persons.

(e) A radio transmitter should not be on the air except when signals are being transmitted. The operator of a radiotelephone station should not press the push-to-talk button except when he intends to speak into the microphone. Radiation from a transmitter may cause interference even when voice is not transmitted.

(f) When radio communications at a station are unreliable or disrupted due to static or fading, it is not a good practice for the operator to continuously call other stations in attempting to make contact because his calls may cause interference to other stations that are not experiencing static or fading.

2. A radiotelephone operator should make an effort to train his voice for most effective radiocommunication. His voice should be loud enough to be distinctly heard by the receiving operator and it should not be too loud since it may become distorted and difficult to understand at the receiving station. He should articulate his words and avoid speaking in a monotone as much as possible. The working distance range of the transmitter is affected to some extent by the loudness of the speaker's voice; if the voice is too low, the maximum distance range of the transmitter cannot be attained and if the voice is too loud the distance range may be reduced to zero due to the signals becoming distorted beyond intelligibility. In noisy locations the operator sometimes cups his hands over the microphone to exclude extraneous noise. Normally, the microphone is held from 2 to 6 inches from the operator's lips.

3. Often in radiotelephone communications a "phonetic alphabet" or word list is useful in identifying letters or words that may sound like other letters or words of different meaning. For example "group" may sound like "scoop," or "bridge" may sound like "ridge." A phonetic alphabet or word list consists of a list of 26 words each word beginning with a different letter for identifying that particular letter. If the letters in "Group" are represented in a phonetic alphabet by Golf, Romeo, Oscar, Uniform and Papa, the word "Group" is transmitted as "Group, G as in Golf, R as in Romeo, O as in Oscar, U as in Uniform, P as in Papa." (See back cover for this alphabet.)

4. PRO-WORDS. It is important in radiotelephone communications that operators use familiar and well known words and phrases in order to insure accuracy and save time from undue repetition of words. Some of the standard procedure words and phrases commonly used are:

Pro-word	*Meaning*
Roger	I have received all of your last transmission satisfactorily.
Wilco	Your last message received, understood, and will be complied with.

Out or Clear	This conversation is ended and no response is expected.
Over	My transmission is ended and I expect a response from you.
Speak Slower	Your transmission is at too fast a speed, speak more slowly.
Say Again	Repeat.
Words Twice	Communication is difficult — give every phrase twice.
Figures	Numerals or numbers follow.
Message Follows	A message that requires recording is about to follow.
This is	This message is coming from.
Wait	I must pause for a few seconds.
Silence	Stay off the air - an emergency message is being transmitted.

5. PROCEDURE. In making a call by radio; first, the call sign or preferably, the name of the called station is given, but no more than 3 times if transmitting conditions are poor; and then followed by the name and call letters of the calling station (3 times if required).

(a) In testing a radiotelephone transmitter the operator should clearly indicate that he is testing, and the station call sign or name of the station, as required by the rules, should be clearly given. Tests should be as brief as possible.

(b) If a radio station is used only for occasional calls, it is a good practice to test the station regularly. Regular tests may reveal defects or faults which, if corrected immediately may prevent delays when communications are necessary. Caution should be observed by persons testing a station to make certain their test message will not interfere with other communications in progress on the same channel.

(c) Technical repairs or adjustments to radiotelephone communication stations are made only by or under the immediate supervision and responsibility of operators holding first or second-class licenses.

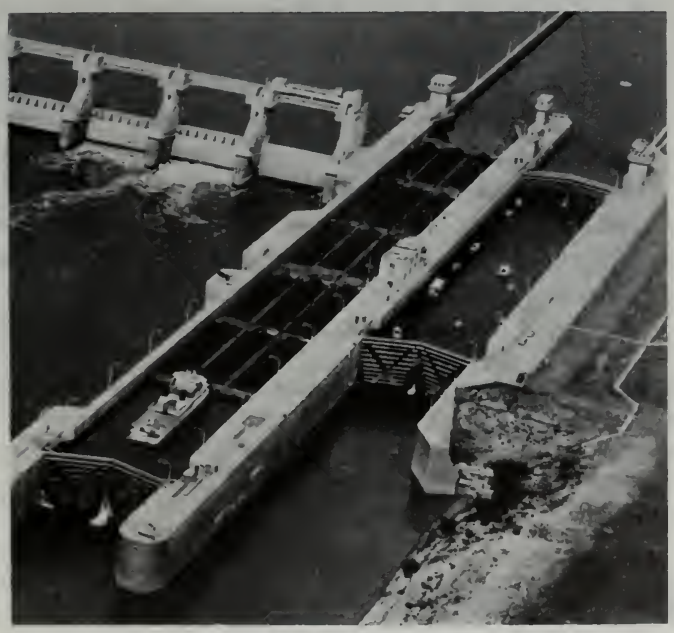
(d) When a licensed operator in charge of a radiotelephone station permits another person to use the microphone and talk over the facilities of the station he should remember that he continues to bear responsibility for the proper operation of the station.

CHAPTER 13

Locks and Dams

River Boating

Some of the finest boating this country offers can be found on the inland waterways of interconnected rivers and lakes. Throughout the United States there are nearly 30,000 miles of inland waterways. The Mississippi River system alone covers more than 12,000 miles. Rivers as a rule seldom offer large open expanses, but they do require unique piloting skills. On the river local knowledge often outweighs many of the fundamental piloting skills. Changing conditions on the rivers put a premium on local knowledge and raise river navigation to an art. Piloting the riverways can be both exciting and interesting. Although the rivers hold no dark secrets, they do have peculiarities which are unique and offer new challenges to the coastal and lake boater.



13-1 River Roads

While the coastal boater keeps close watch on the tides and water depth, the river boater watches overhead clearance, buoys, channels, dikes, wing-dams, and low water dams in back channels. Except for flooding conditions which occur following a heavy rain, the only fluctuation in river level is seasonal. In some of the navigable streams, sudden rains may raise the level several feet in a very few hours.

In the spring, freshets flood down from the headwaters carrying much debris in the strong currents resulting in dangerous conditions. Boaters should use extreme caution, especially in the upper reaches of the river and during periods of reduced visibility. Although dams can hold slight rises in water levels, extreme high water levels must be released from upper pools. At St. Louis, the fluctuation in river level from flood conditions in the early spring to normal levels in the late summer and fall may be from 35 to 40 feet.

Silt and flocculation are responsible for many river problems. Flocculation is a jellied mass of muck which is deposited on the river bed to a depth of several feet. Larger craft can plow through it without much problem and smaller craft are not seriously affected by it. However both silt and flocculation have clogged water strainers and have worn out strut bearings and shafts. Currents, especially during the spring, stir up this silt and additional silt is washed into the river from the banks. It is then carried in suspension by the current until deposited, building up a sand bar or mud bank. This occurs on the inside of bends or where the current is slowed, as at a river mouth or at an entrance to a wide lake or bay.

Indeed, currents are the greatest concern to the river boater. And, until he becomes acquainted with them, they can be both surprising and frustrating. Surface currents, for instance, which affect small craft may run opposite those which pull at large, deep keeled craft. Currents can also change at the junction of rivers, at bends, or where a river widens or narrows. Currents also differ at different points between banks. The friction between water and the river bed tends to slow the current velocity. Hence, you can expect a faster current in the channel, which usually tends toward the outside of bends. A boater who runs downstream in the faster current and upstream in the slower current at the edge of channels can expect to save both time and fuel by letting the current work for him and not fighting it. A boater proceeding upstream along the edge of a channel should be extra cautious and observe his wake closely. A wake will become sharply peaked or broken as it enters shallow water or contacts an under water obstruction, such as a "wing dam". After some experience, the boater will be able to read the surface and get a fair estimate of the conditions below.

Commercial Tows

Most of the inland waterways handle a great deal of commercial traffic. Recreational boaters should give commercial tows a wide berth. It is wise to give such traffic as wide a berth as safety, with respect to channel widths, permits.

Large barges lashed together in one enormous tow may cover many acres. The pleasure boater should appreciate the problems of handling such enormous floats and never jeopardize their activities, regardless of any considerations of right of way. Integrated tows generally are made up of a bowpiece, a group of square ended barges, and a towboat at the stern lashed together in one unit. These tows can be 1,000 feet or more in length. In a narrow channel a big tow or tanker requires the better part of the channel.

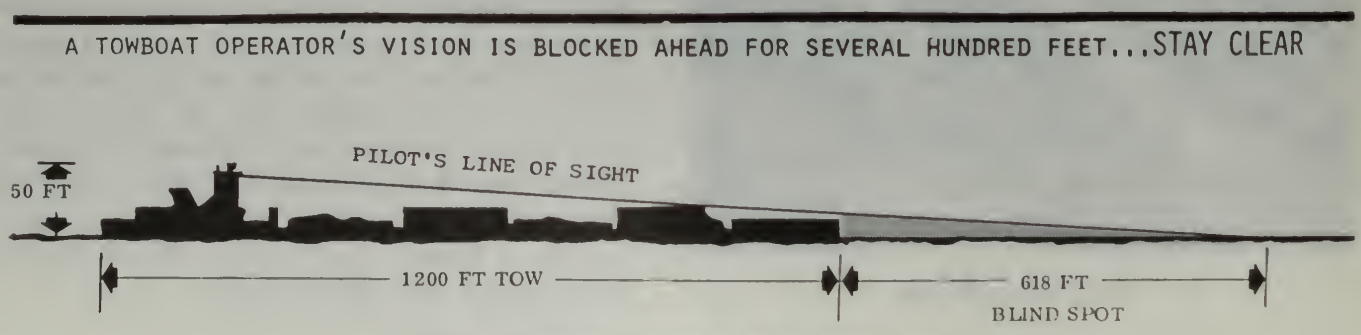
As a commercial tow approaches, you will see a sizeable bow wave built up, running almost the level of her, and the water drawn away by suction to lower the water level at both sides. The wake put out by a commercial tow creates a powerful turbulence extending several hundreds of feet astern of the tow.

Particularly, stay away from the front of tows underway. If you were to stall in such a spot, it may be impossible for the tow to stop or steer clear.

With the weight a commercial tow carries, it may travel half a mile or more before it can come to a full stop. In addition, there is a "blind spot" ahead of the tow that extends for a considerable distance. A good rule of thumb to use is to always keep the pilot house in view.

The swinging effect of a tow must be taken into account at bends in the channel, so it is generally wise to pass on the inside of the bends. Most of the "towing" is accomplished by pushing scows and barges ahead of the tug. This will keep the tow under better control as a single unit. Tugs with tows astern present a real problem to approaching small craft, due to additional swinging.

Special caution is required when running lighted on the rivers at night. At night, to an observer in a small boat, the towboat's lights may be more conspicious than those on the tow far out ahead. Lights on the shore add to the difficulty because of the reflections on the water. When the tows are using powerful searchlights their blinding beams make it impossible to see anything at all.



13-2 Towboat Danger Area (Blind Spot)

13-3 View from Towboat Pilothouse

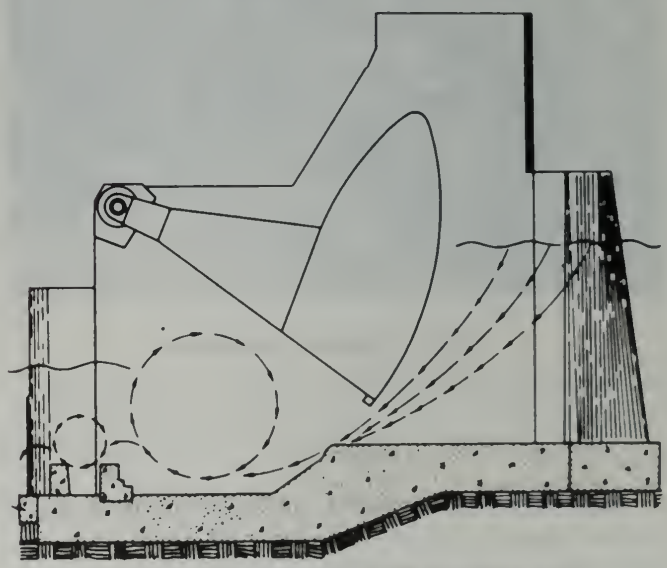
Locks and Dams

Before the development of our present-day system of locks and dams, some rivers were not much more than rapids, with rushing water and many dangerous obstacles. When dams were built at carefully planned locations along the rivers the water filled behind them, creating a series of pools. Since rivers flow "down hill", each downstream pool was somewhat lower in elevation than the preceding one. These dams, of themselves, could have effectively controlled the river but would just as effectively have blocked all river navigation. Consequently, a system of locks was devised to allow vessels to pass from one pool to another. The term "pool stage" indicates the height of water in a pool with reference to the datum *for that pool.* Pool stages are posted on bulletin boards along the river so as to be easily read from a passing vessel. Locations of the bulletin boards and the normal pool gauges are given on the river charts. A normal pool reading on the gauge indicates a minimum channel depth of 9 feet will be available through the area.

The locks and dams were constructed to provide a navigable channel for river traffic. The impounded water in the pool above the dams is released as necessary to maintain a navigable channel of sufficient depth to insure uninterrupted movement of river traffic during the navigation season. These locks and dams present a safety problem equally shared by the owners of small boats, the commercial barge lines, the Coast Guard and the U.S. Army Corps of Engineers whose function it is to build, maintain and operate them. A knowledge of these locks and dams, their types and locations, how to approach, enter and leave them, and a realization of the hazards that are incident to their navigation is essential if the boatman is to use them with confidence and safety.

Construction and Operation of Dams

The average individual's conception of a dam is a solid wall of concrete or earth extending from bank to bank across a stream, with a spillway or overflow section to permit excess impounded waters to escape downstream. The navigation dams on the Mississippi, Illinois and Ohio rivers are quite different. On the Mississippi two types of gates are in common use, the Tainter gate and the Roller gate. Refer to the sketch showing a cross section of a typical dam tainter gate. You can see by the locations of the arrows the manner in which strong currents are created as the water passes through the gates of a dam. Should a boat get too close to the lower or down-stream side of a dam it would be drawn into the dam by the powerful surface current, which actually flows in an upstream direction, and smashed to bits against the steel gate.

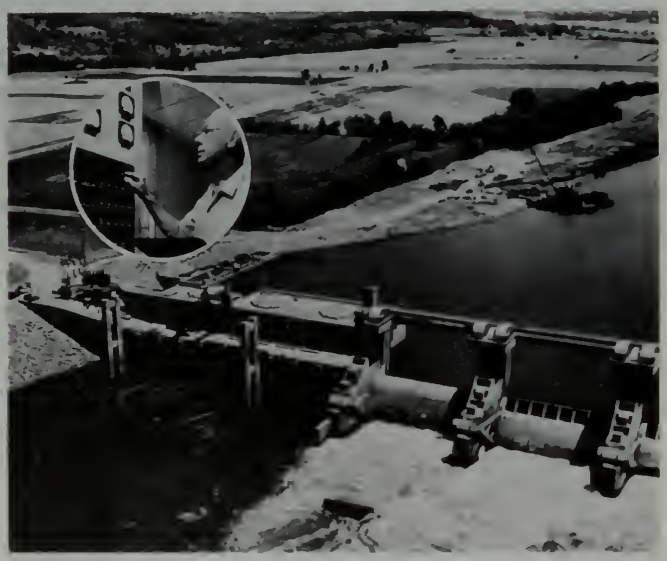


13-4 Typical Dam Tainter Gate

On the upper side of a dam of this type there is a strong suction created by the rush of water underneath. A boat drifting into the dam on the upper side would be in no danger of being drawn under the gate if its occupants would sit still and not become panicky and try to climb out on the gate or jump into the water. The latter course would mean almost

certain death. If the occupants would keep calm and make an effort to cushion the impact of hitting the dam by fending off the boat with a pike pole, boathook or fender, or all three if available, then "sit tight" until help arrives, their chances of survival are fairly good. If this situation should ever happen to you, the thing to remember is to do everything possible to keep the boat afloat, and stay with it as long as possible.

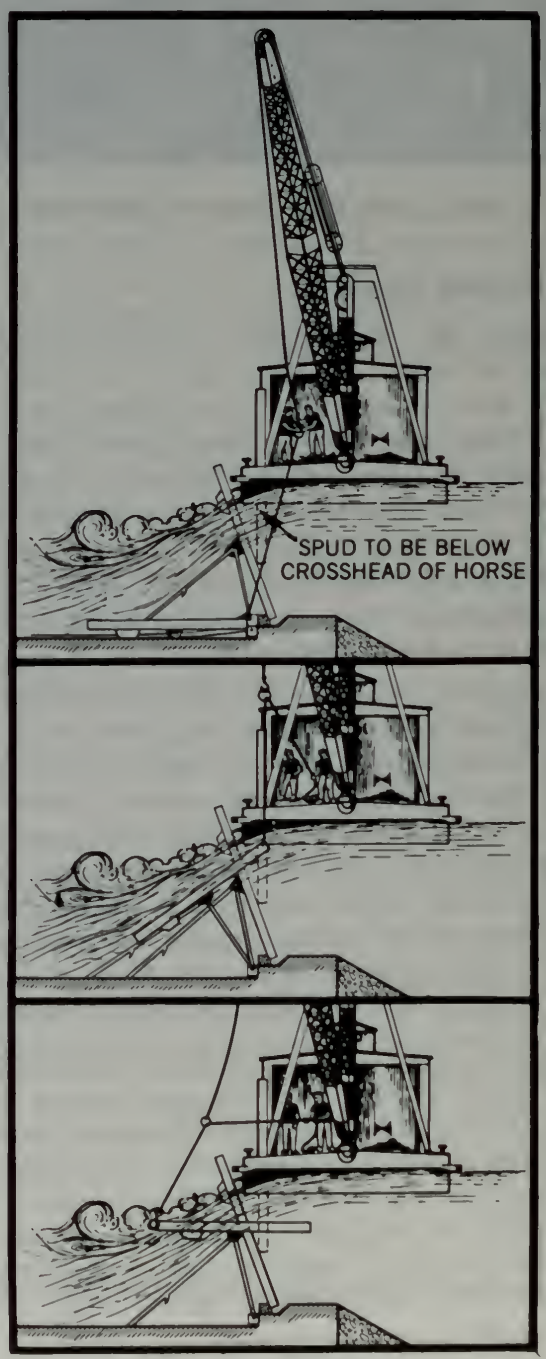
Dams are sometimes controlled remotely. In Illustration 13-5 an operator presses a button (insert). Sixty miles away at Markland Dam the tainter gates rise, sending tons of turbulent water down stream. The boater should be constantly aware of the possibility of such remote control and stay clear of danger areas at all times.



13-5 Tainter Gate Dam

Although tainter gates can be lowered so as to permit water to flow over them, they are normally operated in the partially open position so that the water flows underneath. This is done to permit the mud and silt to pass the dam with the water, thereby precluding the possibility of the river filling up with mud and blocking navigation. The logic in this type of construction can easily be understood by anyone who is familiar with the muddy Mississippi and Missouri rivers.

Another type of dam, the Chanoine Wicket Navigable Pass Dam, is found on the Illinois, Ohio, and Ouachita rivers. It consists of a series of framed timber wickets individually supported so that each wicket can be raised and lowered separately. The wickets are made of oak, reinforced by steel and have a rubber seal attached to the downstream lower edge. They are 3'9" wide and spaced 4'0" on centers with a three inch space between wickets.



13-6 Raising a Typical Wicket

During times of low flow these spaces are filled with 5″ x 5″ wooden timbers, called needles. At a point slightly below center, the wicket is hinge connected to a structural and forged steel frame called a horse, and a forged steel strut called a prop. The horse in turn is pivot connected to the concrete foundation of the dam through a series of steel castings called horse boxes. The lower end of the prop rests in an iron casting called a hurter, embedded in the concrete foundation of the dam. In the raised position, the lower end of the wicket rests against a steel sill casting bolted to the foundation of the dam, and the lower end of the prop is seated in an offset or "seat" in the hurter. The foundation of the dam is supported on steel and wood piling.

A wicket is lowered by pulling it forward using a small derrickboat. The attached prop is guided in its forward movement by a warped surface on the side face of the hurter. This surface guides the lower end of the prop into a groove which by-passes the hurter seat. The wicket is then released, the prop slides freely back in the groove and the wicket falls flat on the sill. As the prop slides freely back in this groove an additional warped surface on that face of the hurter guides it back into an additional groove directly behind the hurter seat. In raising the wicket, the prop follows forward again as the wicket is raised, drops over the seat, and again rests against it as the lower end of the wicket is released and bears against the sill.

When a dam is being raised or lowered all passing craft must use the lock until signaled that the pass is clear. Vessels desiring to wait to use the pass must remain outside the lock area.

When dams are up all vessels in the upper pools not intending to enter the lock are forbidden to approach nearer to the dams than a line extending across the river from the head of the upper guide wall unless authorized to do so by the lockmaster.

On locks at all fixed dams, and at all movable dams *when the dams are up so that there is no navigable pass through the dam,* the following navigation lights will be displayed during hours of darkness:

(1) Three green lights visible through an arc of 360 degrees arranged in a vertical line on the upstream end of the river (guard) wall unless the intermediate wall extends farther upstream. In the later case, the lights will be placed on the upstream end of the intermediate wall.

(2) Two green lights visible through an arc of 360 degrees arranged in a vertical line on the downstream end of the river (guard) wall unless the intermediate wall extends farther downstream. In the later case, the lights will be placed on the downstream end of the intermediate wall.

(3) A single red light visible through an arc of 360 degrees on each end (upstream and downstream) of the land (guide) wall.

If one or more beartraps or weirs are open or partially open, which may cause a "set" in current conditions at the upper approach to the locks, this fact will be indicated by displaying a circular disc five feet in diameter, on or near the light support on the upstream end of the land guide wall during hours of daylight, and will be indicated during hours of darkness by displaying a white light vertically under and five feet below the red light on the upstream end of the land (guide) wall.

At *movable* dams when the dam has been lowered or partly lowered so that there is an *unobstructed navigable pass through the dam* the navigation lights indicated below will be displayed during hours of darkness until lock walls and weir piers are awash.

(1) Three red lights visible through an arc of 360 degrees arranged in a vertical line on the upstream end of the river (guard) wall.

(2) Two red lights visible through an arc of 360 degrees arranged in a vertical line on the downstream end of the river (guard) wall.

(3) A single red light visible through an arc of 360 degrees on each end (upstream and downstream) of the land (guide) wall.

S tay clear of danger zones - 600 feet above and 100 feet below dams.

A pproach dams, at reduced speed, along the shore at the lock.

F or a safe cruise obtain navigation charts from the U.S. Corps of Engineers.

E very boat should carry approved PFD's and a good anchor and line.

T ake precautions to know your position with reference to each lock and dam.

Y ou endanger your life, as well as that of others, when you disregard safety.

Be "Dam" Conscious

During the filling process, it is dangerous to approach near the intake ports in the lock walls above the upstream lock gates because of the powerful suction created by the water as it rushes into the culverts. Small boats must stay clear of the locks until signaled to enter.

During the emptying process a strong undercurrent and suction is created in the lock chamber, adjacent to the lock walls, due to the water rushing into the filling and emptying ports at the bottom of the lock. Occupants of small boats should take care that they do not fall overboard in the lock, for it is very doubtful if anyone could survive a rushing trip through the lock culvert to the river below.

The wearing of a personal flotation device would be no guarantee of safety under these circumstances.

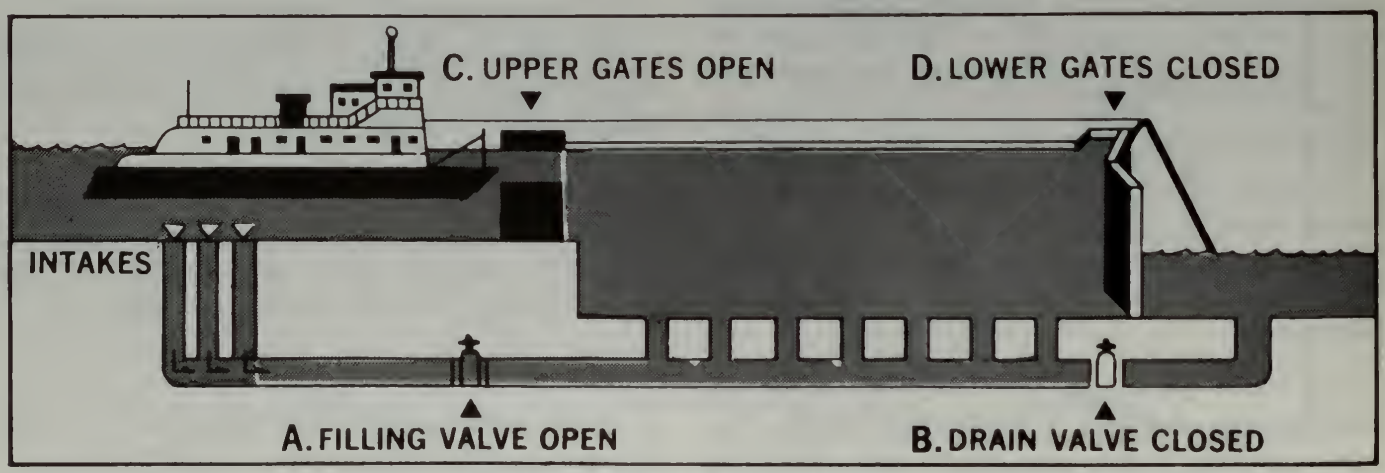
Operation of Locks

While locks come in all shapes and sizes, they all operate on the same principle, that water tends to seek its own level. Basically, a lock is an enclosure with accomodations at both ends (generally called gates) to allow vessels to enter and exit the lock. By a system of culverts and valves, the water level in the lock can be made to align with the pool level of the upstream or downstream side of the lock.

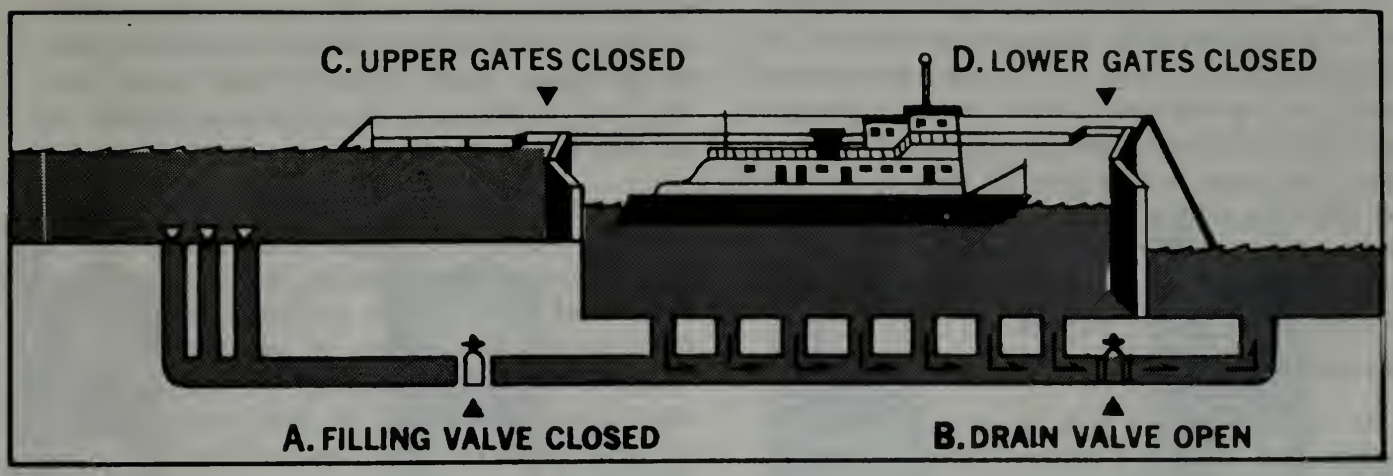
The accompanying sketches show a general plan of a typical lock and the vital parts of the filling and emptying system. These culverts are 10 feet to 12 feet in diameter, with the sections near the valves being square or rectangular in shape.

When the upstream valves are opened and the downstream valves and all miter gates are closed, water will flow from the upper pool through the culverts into the lock chamber filling it to the level of the upper pool. The lock chamber may be emptied to the lower level by opening the downstream valves while keeping the upstream valves and all miter gates closed. The miter gates are operated only when the water level on either side is at the same elevation.

The actual time required to fill or empty the lock depends upon the difference between the upper and lower pool. Under normal river conditions, the lock can be filled or emptied in 7 to 10 minutes.



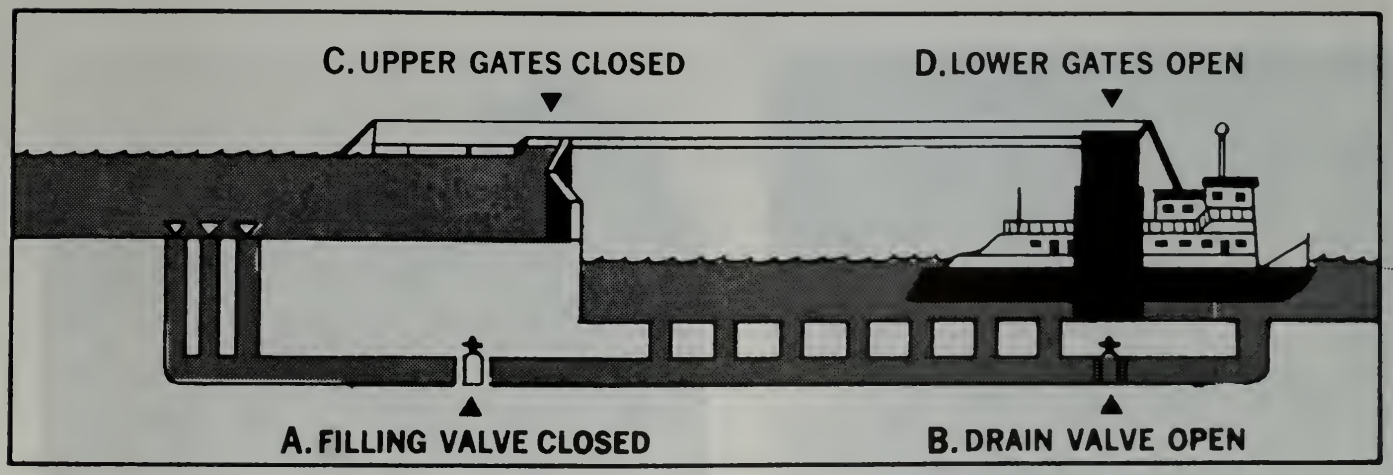
13-7 Lock Open to Upper Pool



13-8 Water Level Lowering

A vessel traveling downstream will enter the lock when the water is at the upper pool level.

The upstream gates are then closed and the water in the lock is allowed to escape through valves and culverts. When the water level in the lock is the same as that of the lower pool, the water will cease to flow out of the lock.



13-9 Lock Open to Lower Pool

The downstream gates are then opened and the vessel leaves the lock to continue on its downstream voyage.

A vessel traveling upstream may then enter the lock. After the vessel is secured in the lock the downstream gates are closed and the water from the upper pool is allowed to enter the lock until the water level in the lock is the same as that of the upper pool. The upper stream gates are then opened and the vessel leaves the lock to continue its upstream voyage. Single vessels are sometimes locked, but more often many vessels of varying sizes are raised or lowered in a single lockage.

Procedure for Lockage

As you approach a lock, local regulations may require you to sound certain whistle signals indicating that you wish to be locked though. Regulations may prohibit you from approaching closer than several hundred feet from the lock while waiting. Additionally, you may be required to maintain your position close to the bank to allow exiting vessels to use the center of the channel as they come out of the lock.

Since the signals used on locks may be lights, whistles, or other devices, we will attempt to briefly describe them. If you normally cruise on a certain section of a particular waterway, you should obtain a copy of the local regulations in force in your waters. Your course instructor will tell you which set of regulations apply and where you will be able to get them. These regulations contain, among other things, signals displayed and utilized by locks and also the proper signals you will be required to sound on your boat's whistle.

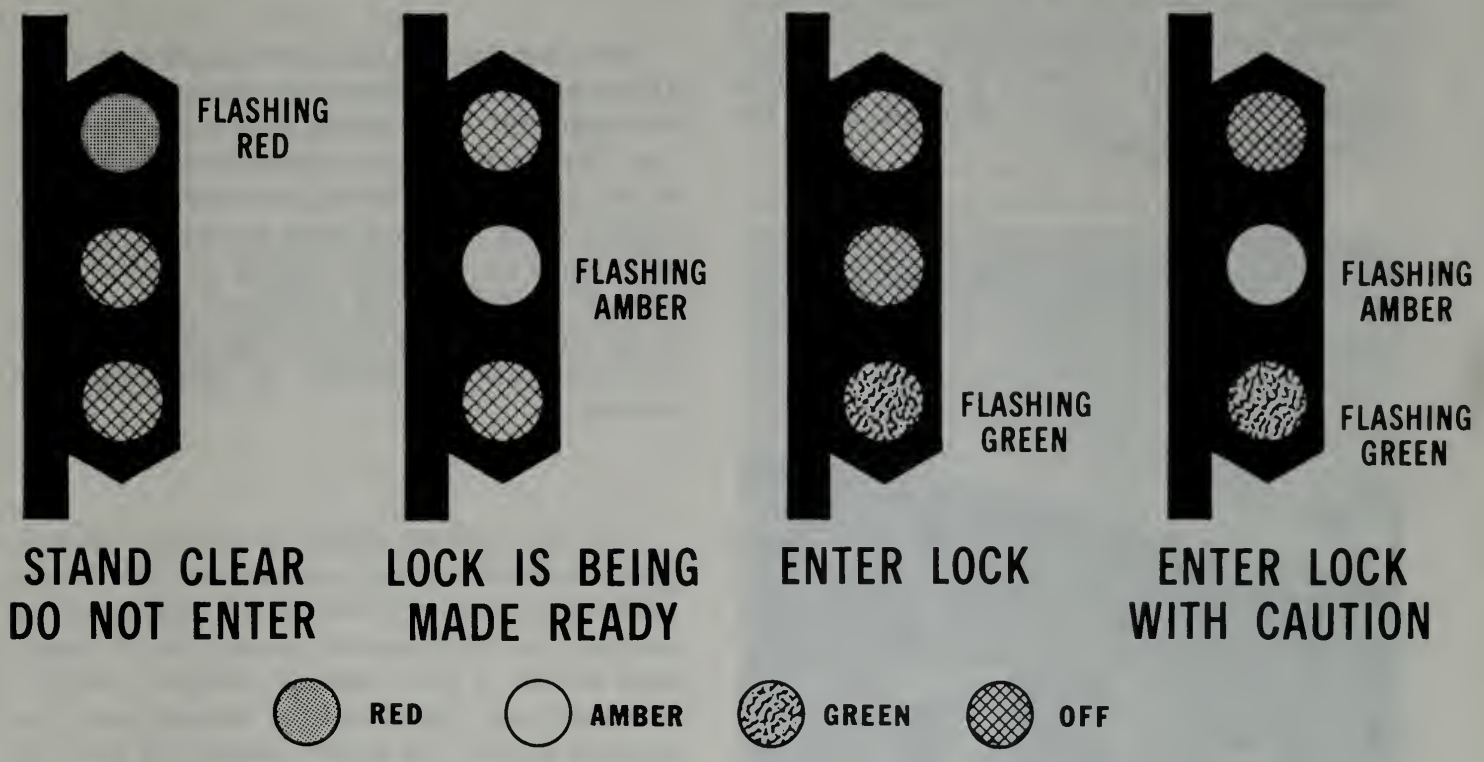
At locks where "small craft signals" are installed, the boat operator may signal the lockman that he desires passage. After signaling, the operator should stand clear with his boat and wait for instruction from the lockman. Many of the locks are radio equipped and can be signaled via radio. Consult your navigational charts for radio equipped locks, the operational frequency and call sign.

Let us assume that you are coming downstream in a boat and desire to pass through a single lock, or landward lock, in case of double locks. When the boat arrives within one-half mile of the lock, you give the proper signal for lockage. The signals vary from one area to another; your course instructor will tell you what signals are used in your area. Do not approach closer than 400 to 600 feet of the upper extremity from the lock wall until you see that the lock gates are open and the lockman signals you to enter. The signal will be from an air horn, or traffic signals, or both. One long blast of the air horn means "Enter landward lock", two long blasts

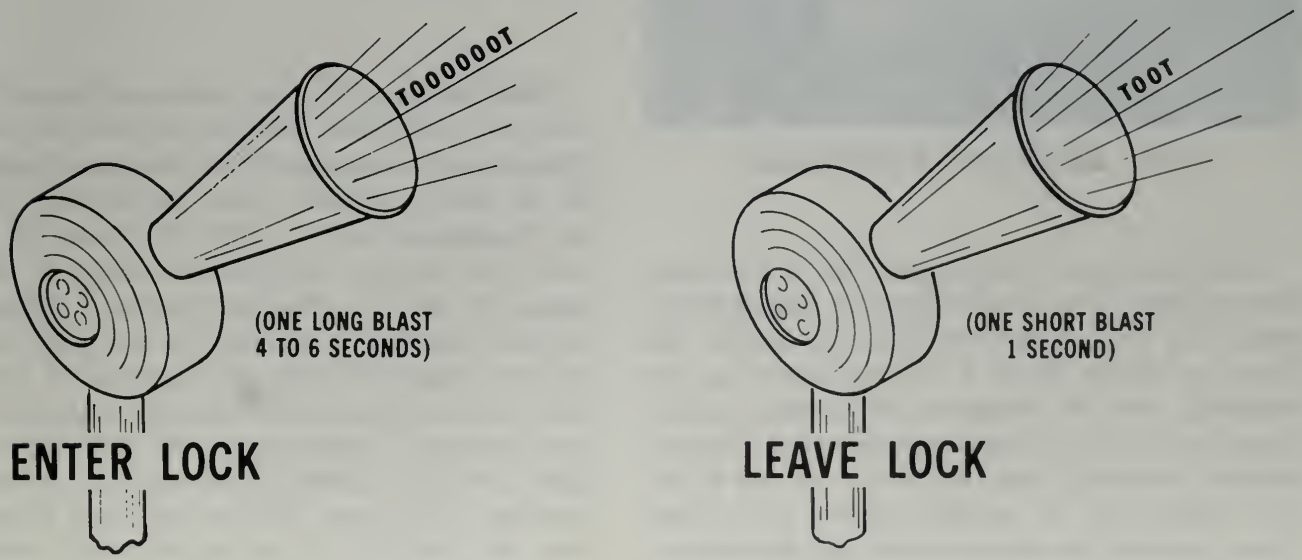
13-10 Dam and Lock Details

13-11 Typical Lock Wall

means "Enter the riverward lock". The traffic signal lights look like automobile traffic lights. A flashing red light means, "Stand Clear Do Not Enter". A flashing amber means, "Approach Lock But Under Full Control". A flashing green means, "Enter Lock".



13-12 Traffic Signal Lights



13-13 Air Horn Signals

After receiving the signal to enter, proceed into the lock. Once inside the lock chamber the boat should proceed to the vicinity of the lockman on the lock wall and be prepared to pass or receive a mooring line. In some areas mooring lines are provided by the lockman and in other areas the mooring lines are provided by the boatman. These mooring lines should be sufficiently strong to serve as a bow line. They should be at least 50 feet long (longer if locking through some locks on the Tennessee Lakes system).

13-14 Securing to a Fixed Bollard

They must reach from the top of the lock wall and have sufficient line to make fast to a ring or bitt on deck. The end of the line that is passed to the lockman should have a 12-inch eye-splice for dropping over the checkpost, the operator should always wear USCG approved personal flotation devices. Mooring lines should not be tied to the boat. They must be carefully tended at all times. Extra care must be exercised during a downbound lockage that the mooring lines are not fouled when the water level in the lock is being lowered. A fouled line may result in a boat hanging up on the line and could cause serious damage or even capsize the boat. Be prepared to cast off lines in an emergency. Use plenty of fenders to protect the hull from damage from rough or dirty lock walls.

Some locks have mooring pins in the lock walls. Others have floating bitts which raise or lower with the water level. In either case the lockman will direct you. Never moor a boat to ladder rungs embedded in the lock walls. This might cause the boat to capsize when the water level is lowered. Do not stand up in an open boat or walk around on deck without wearing a PFD. Vessels are not permitted to drift around within the lock while the water level is being raised or lowered. All vessels must be moored.

After all vessels are securely moored and the lock gates are closed, the lock is allowed to fill or empty. While being raised or lowered it will be necessary to take in or pay out line as the case may be. All vessels must remain in their assigned positions until the lock gates are opened and the lockman gives the signal to depart. The signal to depart will be given from the air horn, one short blast means, "Leave landward lock", two short blasts means, "Leave riverward lock".

After the signal is given, boats shall depart from the lock in the same order as they entered, except when directed otherwise by the lockman. In the case of a small pleasure boat making a lockage simultaneously with a commercial tow, the small boat will usually be directed verbally to depart ahead of the tow. This is done as a precaution against accident or damage to the more fragile pleasure boat and can be accomplished without delay if properly executed. In no event should small craft attempt to depart from the lock before lock gates are fully recessed, as the wake can do serious damage to the gates. As the small boat leaves the lock, he should head for the channel, keeping a sharp lookout for craft approaching from the other direction.

Certain priorities have been established by the Secretary of the Army (under authority of Section 7 of the River and Harbor Act of August 8, 1917) for safe and efficient passage of various types of craft which use the inland waterways. The priorities thus established are as follows:

1st - U. S. Military Craft
2nd - Vessels Carrying U.S. Mail
3rd - Commercial Passenger Craft
4th - Commercial Tows
5th - Commercial Fishermen
6th - Pleasure Boats

Under certain coditions small craft (pleasure boats) may be locked through with other craft having a higher priority, but only when no delay is occasioned thereby and the safety of either craft is not jeopardized.

The lockmen have been given the same authority over your boat in the lock as traffic policemen have over your car at intersections. For your safety you must obey their instructions.

Every boat should have aboard a copy of the regulations governing navigation on the rivers in their area. Small boat operators should study and refer to these "Regulations" whenever in doubt as to the proper procedure in making a lockage. Your course instructor has prepared handouts for this purpose and you should study them closely.

It's only natural to have feelings of apprehension, but if you will put to practice what you have learned in this lesson, you will have unlimited pleasure in river boating. Have a safe and pleasant journey.

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AIDS TO NAVIGATION ON NAVIGABLE WATERS
except Western Rivers and Intracoastal Waterway

LATERAL SYSTEM AS SEEN ENTERING FROM SEAWARD

PORT SIDE
ODD NUMBERED AIDS
□ WHITE OR ■ GREEN LIGHTS

FIXED
FLASHING
OCCULTING
QUICK FLASHING

LIGHTED BUOY • "9" Ra ref

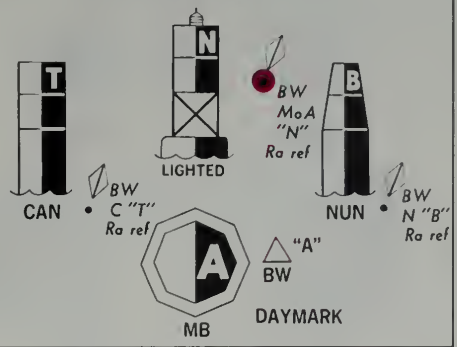
CAN • "7" Ra ref

SB 1 "1" ▲ DAYMARKS SW 3 △ "3" W

PB 5 POINTER ▲ "5"

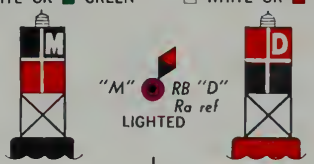
MID CHANNEL
NO NUMBERS—MAY BE LETTERED
□ WHITE LIGHT ONLY

MORSE CODE



JUNCTION
MARK JUNCTIONS AND OBSTRUCTIONS
NO NUMBERS—MAY BE LETTERED
INTERRUPTED QUICK FLASHING

□ WHITE OR ■ GREEN □ WHITE OR ■ RED



PREFERRED CHANNEL TO STARBOARD
TOPMOST BAND BLACK
CAN • RB C "N" Ra ref

PREFERRED CHANNEL TO PORT
TOPMOST BAND RED
NUN • RB N "L" Ra ref

JB L △ "L" RB

JR J △ "J" RB

STARBOARD SIDE
EVEN NUMBERED AIDS
□ WHITE OR ■ RED LIGHTS

FIXED
FLASHING
OCCULTING
QUICK FLASHING

LIGHTED BUOY R "B" Ra ref

NUN R N "6" Ra ref

TR 4 DAYMARK R ▲ "4"

PR 6 POINTER R ▲ "6"

BUOYS HAVING NO LATERAL SIGNIFICANCE—ALL WATERS

SHAPE HAS NO SIGNIFICANCE
NO NUMBERS—MAY BE LETTERED
MAY BE LIGHTED
ANY COLOR LIGHT EXCEPT RED OR GREEN

FIXED
FLASHING
OCCULTING

WO, C Ra ref
SPECIAL PURPOSE

Y C Ra ref
QUARANTINE ANCHORAGE

W C "N" Ra ref
ANCHORAGE

BW C Ra ref
FISH NET AREA

GW C Ra ref
DREDGING

UNLIGHTED

DANGER

EXCLUSION AREA

DAYMARKS HAVING NO LATERAL SIGNIFICANCE
MAY BE LETTERED

NW

NR

NB

AIDS TO NAVIGATION ON THE INTRACOASTAL WATERWAY

AS SEEN ENTERING FROM NORTH AND EAST—PROCEEDING TO SOUTH AND WEST

PORT SIDE
ODD NUMBERED AIDS
□ WHITE OR ■ GREEN LIGHTS
FIXED ——— OCCULTING — — —
FLASHING - - - QUICK FLASHING ·····

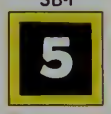
LIGHTED BUOY

"3" Ra ref

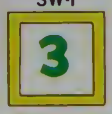
CAN

C "9" Ra ref

SB-I

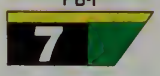


SW-I



"5" DAYMARKS "3" W

PB-I



"7"

POINTER

JUNCTION
MARK JUNCTIONS AND OBSTRUCTIONS
NO NUMBERS—MAY BE LETTERED
INTERRUPTED QUICK FLASHING ····· ····· ·····

□ WHITE OR ■ GREEN LIGHTS □ WHITE OR ■ RED LIGHTS

RB "J" Ra ref "N" LIGHTED

PREFERRED CHANNEL

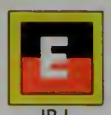
TO STARBOARD TOPMOST BAND BLACK | TO PORT TOPMOST BAND RED

CAN

RB C "A" Ra ref

RB N "S" Ra ref

NUN



"E" RB

JB-I

"D" RB

JR-I

MID CHANNEL DAYMARK

"C" BW

MB-I

STARBOARD SIDE
EVEN NUMBERED AIDS
□ WHITE OR ■ RED LIGHTS
FIXED ——— OCCULTING — — —
FLASHING - - - QUICK FLASHING ·····

LIGHTED BUOY

R "8" Ra ref

NUN

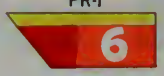
R N "6" Ra ref

TR-I

R "4"

DAYMARK

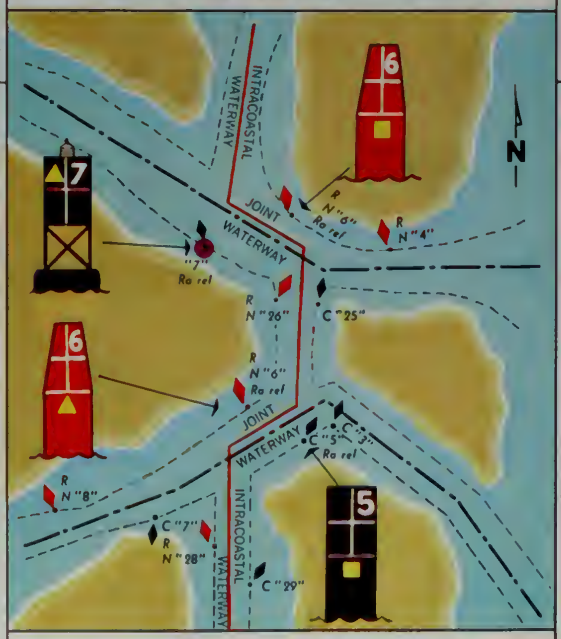
PR-I



R "6"

POINTER

DUAL PURPOSE MARKING USED WHERE THE ICW AND OTHER WATERWAYS COINCIDE



When following the ICW from New Jersey through Texas, a △ should be kept to your starboard hand and a □ should be kept to your port hand, regardless of the color of the aid on which they appear.

SB-SY

"3"

C "5" Ra ref

DUAL PURPOSE DAYMARKS

DUAL PURPOSE BUOYS

TR-SY

R "6"

R N "6" Ra ref

JB-SY

"A" RB

JR-SY

"B" RB

TR-TY

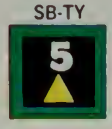
R "6"

R N "6" Ra ref

DUAL PURPOSE DAYMARKS

DUAL PURPOSE BUOYS

SB-TY



"5"

C "5" Ra ref

JB-TY

"C" RB

JR-TY

"D" RB

AIDS TO NAVIGATION ON WESTERN RIVERS

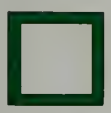
AS SEEN ENTERING FROM SEAWARD

PORT SIDE

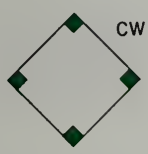
□ WHITE OR ■ GREEN LIGHTS
FLASHING

LIGHTED BUOY

CAN



PASSING DAYMARK



CROSSING DAYMARK

176.9

MILE BOARD

JUNCTION

MARK JUNCTIONS AND OBSTRUCTIONS
INTERRUPTED QUICK FLASHING

PREFERRED CHANNEL TO STARBOARD
TOPMOST BAND BLACK

PREFERRED CHANNEL TO PORT
TOPMOST BAND RED

□ WHITE OR
■ GREEN LIGHTS

LIGHTED

□ WHITE OR
■ RED LIGHTS

CAN

NUN

JB

JR

STARBOARD SIDE

□ WHITE OR ■ RED LIGHTS
GROUP FLASHING (2)

LIGHTED BUOY

NUN

PASSING DAYMARK

CROSSING DAYMARK

123.5

MILE BOARD

RANGE DAYMARKS

NAVIGABLE WATERS EXCEPT ICW

INTRACOASTAL WATERWAY

MAY BE LETTERED

UNIFORM STATE WATERWAY MARKING SYSTEM

STATE WATERS AND DESIGNATED STATE WATERS FOR PRIVATE AIDS TO NAVIGATION

REGULATORY MARKERS

BOAT EXCLUSION AREA

EXPLANATION MAY BE PLACED OUTSIDE THE CROSSED DIAMOND SHAPE, SUCH AS DAM, RAPIDS, SWIM AREA, ETC.

DANGER

THE NATURE OF DANGER MAY BE INDICATED INSIDE THE DIAMOND SHAPE, SUCH AS ROCK, WRECK, SHOAL, DAM, ETC.

CONTROLLED AREA

TYPE OF CONTROL IS INDICATED IN THE CIRCLE, SUCH AS 5 MPH, NO ANCHORING, ETC.

INFORMATION

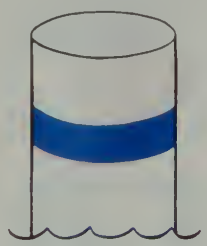
FOR DISPLAYING INFORMATION SUCH AS DIRECTIONS, DISTANCES, LOCATIONS, ETC.

BUOY USED TO DISPLAY REGULATORY MARKERS

MAY SHOW WHITE LIGHT
MAY BE LETTERED

AIDS TO NAVIGATION

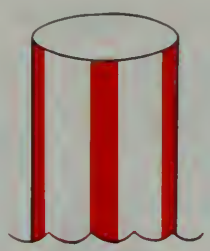
MAY SHOW WHITE REFLECTOR OR LIGHT



MOORING BUOY

WHITE WITH BLUE BAND

MAY SHOW WHITE REFLECTOR OR LIGHT

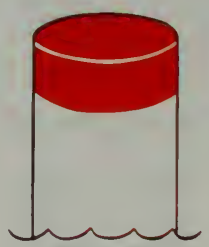


RED-STRIPED WHITE BUOY

MAY BE LETTERED
DO NOT PASS BETWEEN BUOY AND NEAREST SHORE

BLACK-TOPPED WHITE BUOY

MAY BE NUMBERED
PASS TO NORTH OR EAST OF BUOY



RED-TOPPED WHITE BUOY

PASS TO SOUTH OR WEST OF BUOY

CARDINAL SYSTEM

MAY SHOW GREEN REFLECTOR OR LIGHT

MAY SHOW RED REFLECTOR OR LIGHT

SOLID RED AND SOLID BLACK BUOYS

USUALLY FOUND IN PAIRS
PASS BETWEEN THESE BUOYS

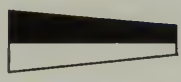
PORT SIDE — LOOKING UPSTREAM — STARBOARD SIDE

LATERAL SYSTEM

MORSE CODE, CODE FLAGS, PENNANTS, AND PHONETIC ALPHABET

Alphabet Flags	Letter	Phonetic Alphabet	Pronunciation Guide	International Morse Code
	A	ALFA	AL FAH	. —
	B	BRAVO	BRAH VOH	— ...
	C	CHARLIE	CHAR LEE	— . — .
	D	DELTA	DELL TAH	— ..
	E	ECHO	ECK OH	.
	F	FOXTROT	FOKS TROT	.. — .
	G	GOLF	GOLF	— — .
	H	HOTEL	HOH TELL	....
	I	INDIA	IN DEE AH	..
	J	JULIETT	JEW LEE ETT	. — — —
	K	KILO	KEY LOH	— . —
	L	LIMA	LEE MAH	. — ..
	M	MIKE	MIKE	— —
	N	NOVEMBER	NO VEM BER	— .
	O	OSCAR	OSS CAH	— — —
	P	PAPA	PAH PAH	. — — .
	Q	QUEBEC	KEH BECK	— — . —
	R	ROMEO	ROW ME OH	. — .
	S	SIERRA	SEE AIR RAH	...
	T	TANGO	TANG GO	—

Alphabet Flags	Letter	Phonetic Alphabet	Pronunciation Guide	International Morse Code
	U	UNIFORM	YOU NEE FORM	.. —
	V	VICTOR	VIK TAH	... —
	W	WHISKEY	WISS KEY	. — —
	X	XRAY	ECKS RAY	— .. —
	Y	YANKEE	YANG KEY	— . — —
	Z	ZULU	ZOO LOO	— — ..

Numeral Pennants	Number	Pronunciation Guide	International Morse Code
	1	WUN	. — — — —
	2	TOO	.. — — —
	3	THUH REE	... — —
	4	FO WER	.... —
	5	FI YIV	.....
	6	SIX	— ....
	7	SEVEN	— — ...
	8	ATE	— — — ..
	9	NINER	— — — .
	0	ZERO	— — — — —

REPEATERS


FIRST REPEATER


THIRD REPEATER


SECOND REPEATER


CODE AND ANSWERING PENNANT